ESD-TDR-64-397

(FINAL REPORT)

AN/TPN-14 PRECISION APPROACH RADAR (PAR) ANALYSIS

TECHNICAL DOCUMENTARY REPORT NO. ESD-TDR-64-397

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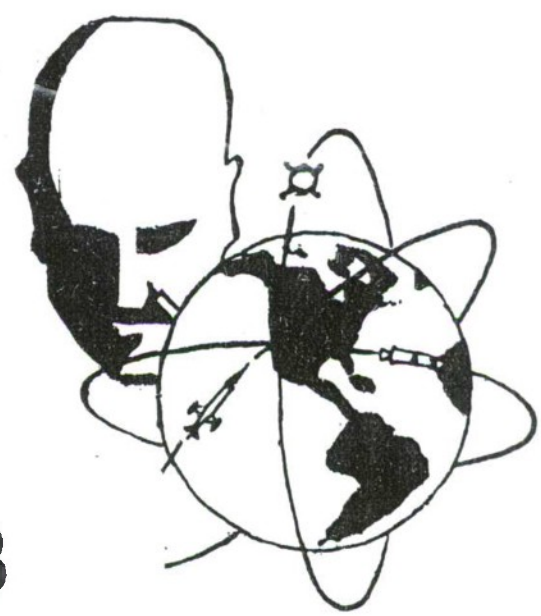

System 482L

(Prepared under Contract No. AF 19 (628)-2951 by Westinghouse Defense and Space Center, Field Support Department, Baltimore, Maryland.)

DDC AVAILABILITY NOTICES

FOREWORD

This report was prepared by Westinghouse Electric Corporation Defense and Space Center under USAF Contract No. AF 19(628)-2951. The work was administered under the direction of Mr. B. F. Greene, Jr., Chief, Technical Support Division, 482L System Program Office, DSM.

This report covers work and study conducted from April 1963 to April 1964.

ABSTRACT

The purpose of the contract for which this report is written is the study and analysis of the AN/TPN-14 PAR, and the subsequent reporting of recommendations of design modifications for corrections of deficiencies.

Tests were conducted and observed, and data collected for the purpose of analyzing system performance, and the equipment specification was reviewed for possible improvements.

This report includes the analyses which resulted from the foregoing studies, in two sections; suggested improvements in the manner of stating equipment requirements in the specification are given, and for the equipment, deficiencies are discussed, solutions suggested, and recommendations made as to whether early correction or acceptance of the existing conditions is preferable.

Publication of this technical documentary report ESD-TDR-64-397 does not constitute Air Force approval of its findings or conclusions. It is published only for the exchange and stimulation of ideas.

KEY WORD LIST

1. COMMUNICATION SYSTEMS
2. RADAR
3. NAVIGATIONAL AIDS
4. PORTABLE
5. GUIDANCE
6. PERFORMANCE TESTS
7. DESIGN
8. DATA
9. ANALYSIS

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SECTION 1

INTRODUCTION

1.0 The AN/TPN-14 is a Precision Approach Radar (PAR) designed and built by Gilfillan Bros., Inc., and forms a subsystem of the AN/TSQ-47 Air Traffic Control System which is being furnished to the Air Force (ESD) by the Radio Corporation of America. The object of Contract AF19(628)-2951, extending from 15 April 1963 to 14 July 1964, has been the study and analysis of the PAR and its specification, concluding with a final report giving the recommendations for improvements in both the specification and the equipment.

Originally, it was planned that all qualification and acceptance testing on the AN/TPN-14 would be completed prior to the end of the "work period" which extended from 15 April 1963 to 14 April 1964. However, due to several schedule slippages, this had not been accomplished; most qualification tests had been accomplished, but reports had been received on only about 75% of the completed tests. Acceptance tests are not to be conducted until all qualification tests have been satisfactorily completed. Therefore, although this is the final report on the study and effort expended on this contract, it cannot be considered as the final report on the AN/TPN-14. Attempts were made to obtain all available qualification test results in order to analyze the deficiencies encountered in the PAR; RFI testing in accordance with MIL-I-26600 is the only qualification test for which the initial results are not known. The RFI and acceptance test results may necessitate further comments by other personnel.

The approach taken in this report, in making the various recommendations regarding the specification and the equipment, is that of suggesting the minimum modification which will achieve the desired system operation. There has been no attempt to include exotic modifications and/or redesign of the equipment, such as suggesting the substitution of phased array antennae for the existing ones, as such an approach is outside the scope of this contract.

The recommendations given herein are separated into two sections: 2.0, The Specification, and 3.0, The Equipment; these are further divided according to the particular type of recommendations made in each area. There are instances in each section (2.0 and 3.0) where there is some crossover into facets of the other section; it is inherently very difficult, if not impossible, to separate consideration of specification from consideration of equipment.

Among the illustrations, Figures 1 through 5 are primarily to acquaint the reader with the AN/TPN-14 physical configuration; figures 6a, 6b and 6c, showing the stowage kit, are to illustrate the problems of stowing the equipment, which are described in paragraph 3.1.6. Figures 7 through 9 illustrate the theoretical cosecanted azimuth and elevation antenna patterns, and flight test data for various transmission modes. Figures 10 through 15 are photographs taken at the PAR Indicator to illustrate the possible problems of nearby terrain clutter, and the effect on this clutter of various operational modes. Figure 16 is a foldout guide for the identification of the salient features of figure 10 through 15. Figures 5, 6a, 6b and 6c were extracted from AN/TPN-14 Technical Order.

Figure 1. AN/TPN-14, Showing Personnel Entrance

Figure 2. AN/TPN-14, Showing PAR Elevation Cosecanting Reflector

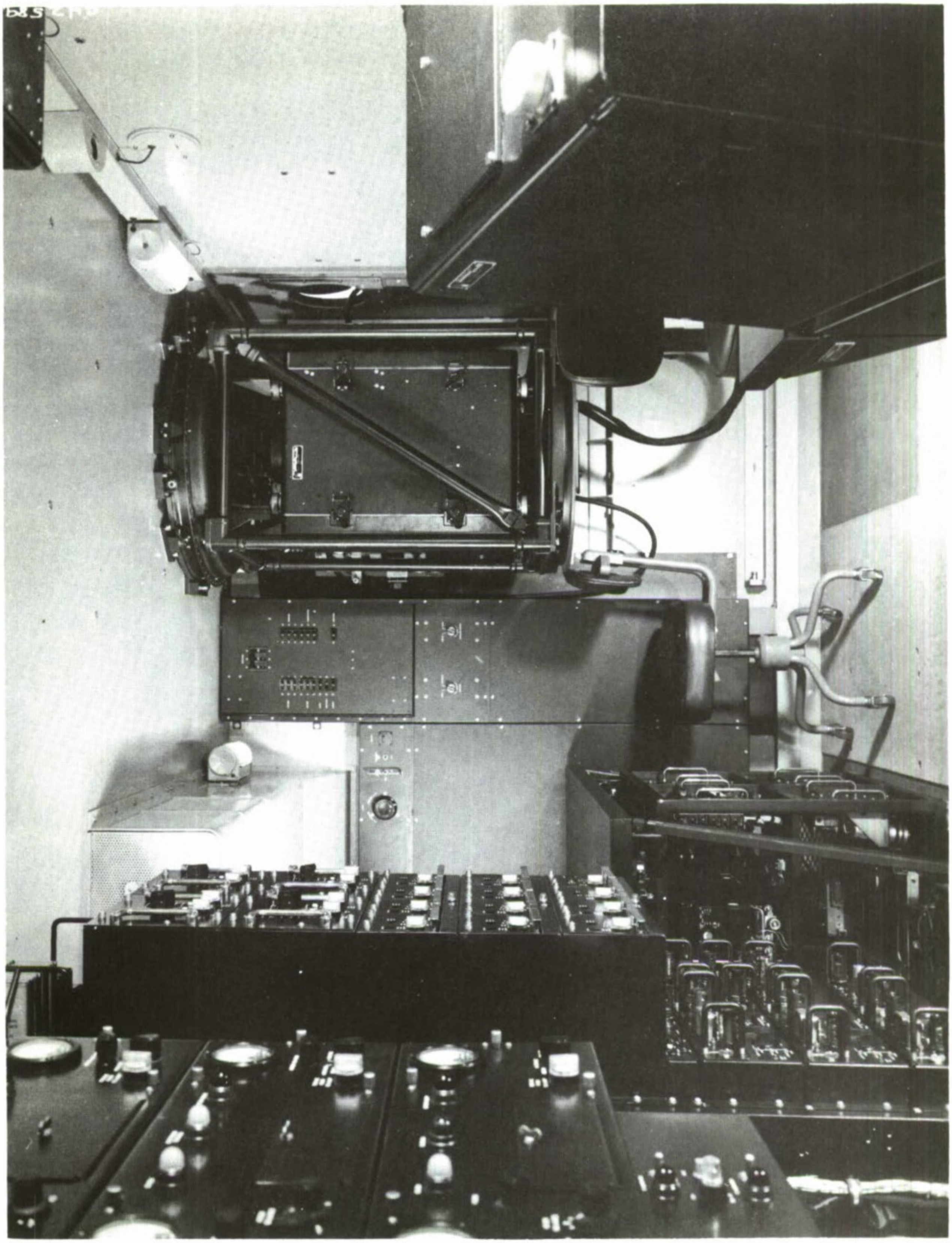

Figure 3. AN/TPN-14 Internal View From Entrance

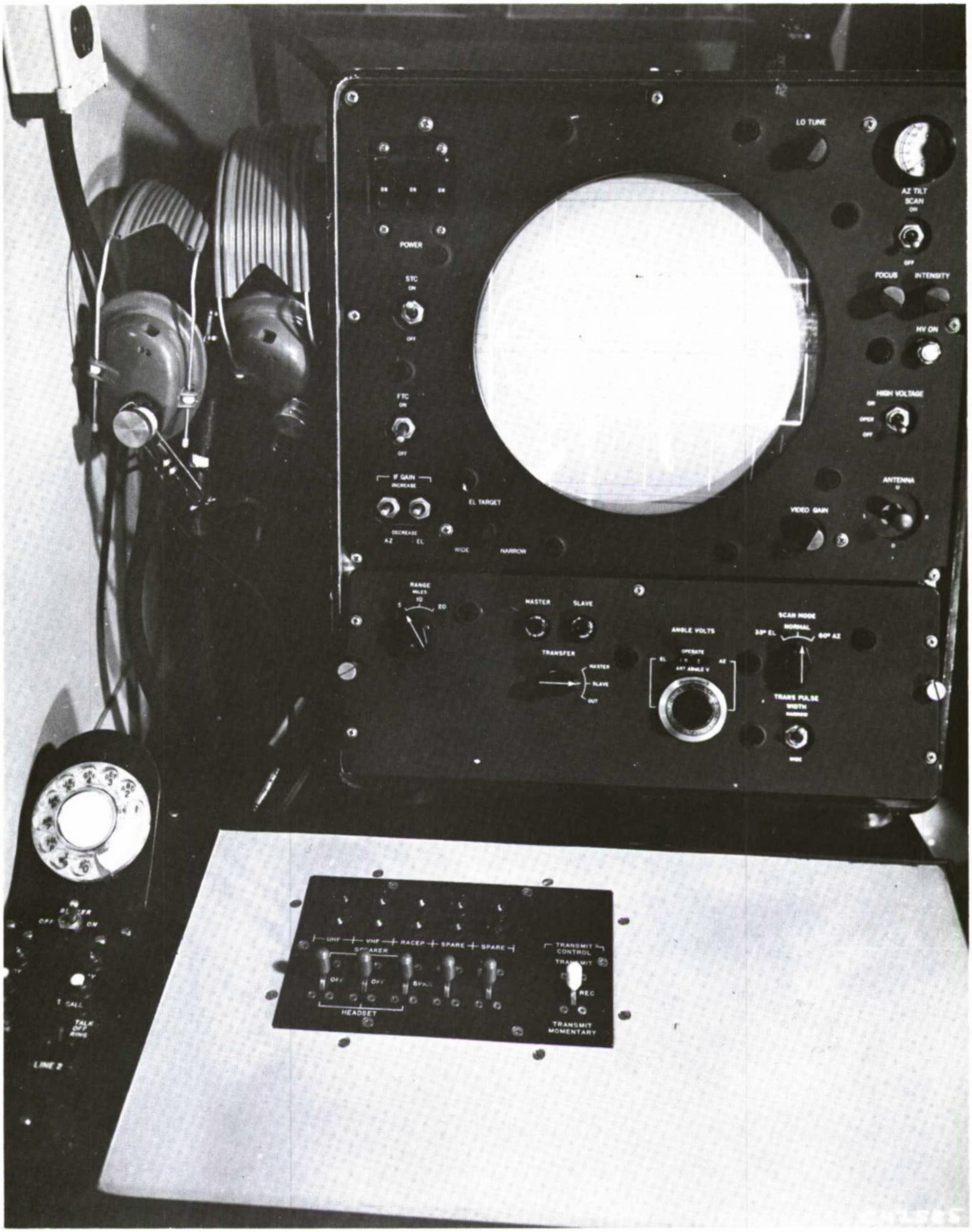

Figure 4. AN/TPN-14 Control Indicator

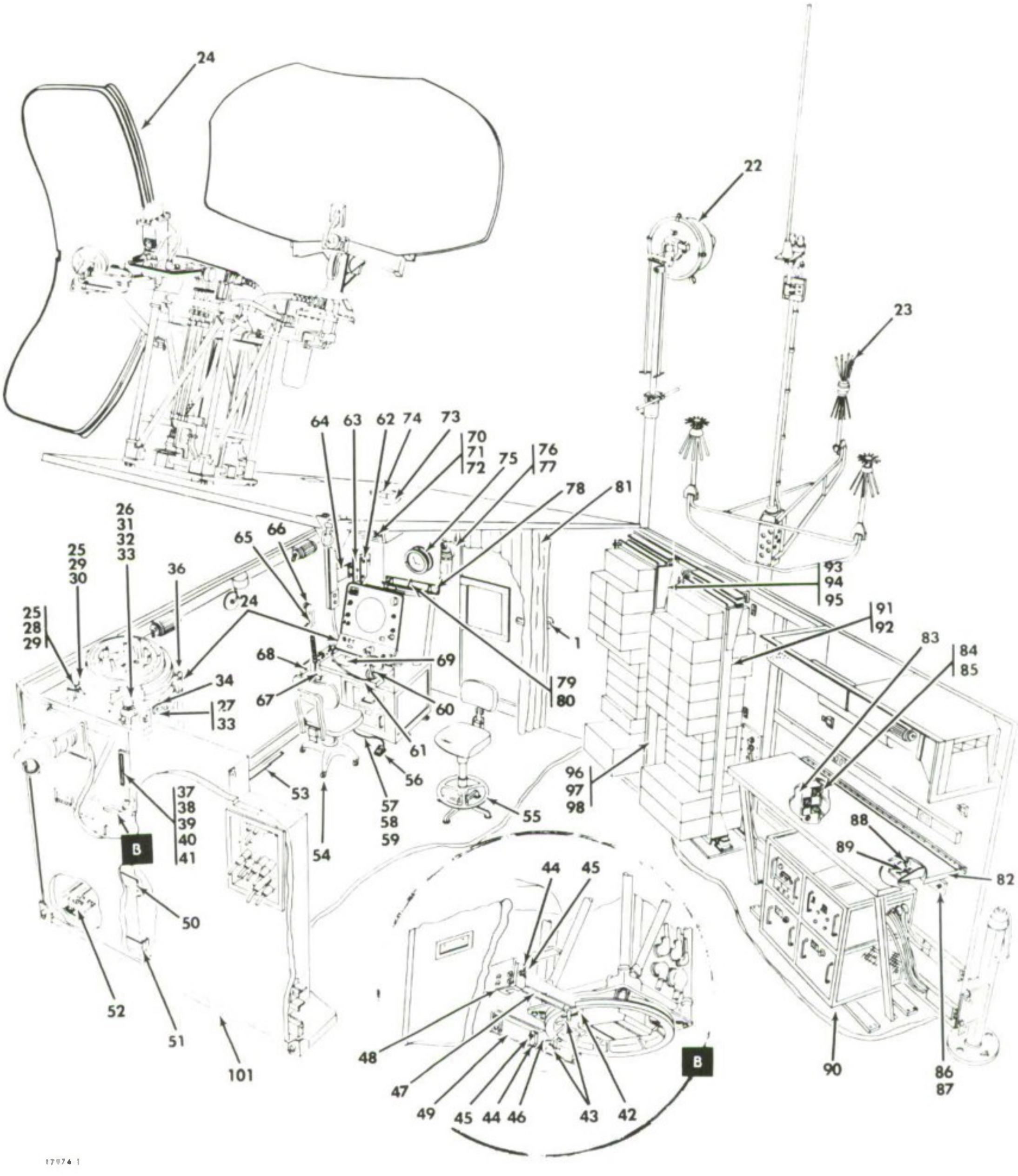

Figure 5. AN/TPN-14 Exploded Interior View (See Table 1)

TABLE 1

FIG. AND INDEX NO.	MFR PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7 8 9	MFR CODE	UNITS PER ASSY	USABLE ON CODE
1 -	116100	RADAR SET AN/TPN-14		REF	
- 1	116919	. PLATE, IDENTIFICATION		1	
- 2	1730400	. TOOL KIT CFE	49671	1	
- 3	1730432	. CABLE ASSY CFE	49671	2	
- 4	1730431	. CABLE ASSY CFE	49671	2	
- 5	1730430	. GENERATOR SET CFE	49671	2	
- 6	173043A	. AIR DUCT CFE	49671	2	
		ATTACHING PARTS			
	1730782	. CONTAINER, AIR DUCT CFE	49671	2	
		---*---			
- 7	1730435	. CABLE ASSY CFE	49671	1	
- 8	1730433	. AIR CONDITIONER CFE	49671	1	
- 9	116202	. CABLE INSTALLATION, EXTERNAL		1	
	9A46	. . ROD	90190	1	
	65A1	. . CLAMP	90190	1	
	116470	. . CABLE ASSY		1	
	GS10-201	. . . MARKER, CABLE		2	
	33469	. . . TERMINAL	00779	1	
	CO-01-HOE 1/A 0560	. . . CABLE		AR	
	116207	. SIMULATOR, RADAR TARGET		6	
- 10	93372-133	. . PLATE, IDENTIFICATION		1	
- 11	116852	. . BRACKET, REFLECTOR MOUNT		1	
		ATTACHING PARTS			
	MS35234-63	. . SCREW		3	
	MS35338-81	. . WASHER		3	
	MS15795-308	. . WASHER		3	
	MS35650-104	. . NUT		3	
		---*---			
- 12	BLC4GT28L10	. . PIN	84256	3	
- 13	116851	. . TUBE, SUPPORT		1	
		ATTACHING PARTS			
	MS35233-17	. . SCREW		1	
	MS35338-78	. . WASHER		1	
	MS15795-303	. . WASHER		1	
	MS35649-A4	. . NUT		1	
		---*---			
- 1A	116760	. . STAKE, GROUND		1	
- 15	MS16562-257	. . . PIN		1	
	116805	. . REFLECTOR, CORNER, FRANGIBLE		1	
- 16	H323-4-2-1	. . . PLUNGER	83014	3	
- 17	H322-4-1	. . . GROMMET	83014	3	
- 18	116805-3	. . . SPACER		3	
- 19	116805-2	. . . LINER		1	
- 20	116805-1	. . . REFLECTOR		1	
- 21	116630	. . POLARIZER, FRANGIBLE ASSY		1	
- 22	1730457	. ANTENNA GROUP CFE	49671	1	
- 23	116197	. UHF VHF COMMUNICATIONS ANTENNA ASSY SEE FIG. 8		1	
- 24	116101	. RADAR SET GROUP OA-4635/TPN-14 SEE T.O. 31P5-2TPN-14 A		1	
		ATTACHING PARTS			
- 25	MS35307-60	. SCREW		4	
- 26	MS35307-10	. SCREW		4	
- 27	MS35461-3	. SCREW		A	
- 28	MS35307-62	. SCREW		3	
- 29	MS35338-8A	. WASHER		7	
- 30	MS15795-31A	. WASHER		7	
- 31	MS35338-82	. WASHER		A	
- 32	MS15795-310	. WASHER		4	
- 33	MS35338-80	. WASHER		A	
		---*---			
- 34	MS90064-14	. PACKING, PREFORMED		3	
- 35	116777	. SPACER, TRANSMITTER		4	
- 36	117123	. STOP, ANTENNA MOUNT		1	
		ATTACHING PARTS			
	MS35461-56	. SCREW		1	
	MS35338-84	. WASHER		1	
		---*---			
	MS16555-640	. . PIN		1	
	117123-1	. . STOP		1	

TABLE 1 (Continued)

FIG. AND INDEX NO.	MFR PART NUMBER	1 2 3 4 5 6 7 8 9 DESCRIPTION	MFR CODE	UNITS PER ASSY	USABLE ON CODE
1 - 37	116990-2	. CLAMP		2	
		ATTACHING PARTS			
	MS35233-44	. SCREW		6	
	MS35338-80	. WASHER		6	
	MS15795-307	. WASHER		6	
	MS35649-84	. NUT		6	
		---*---			
- 38	117062	. STOWAGE, IAR ALLIGNMENT FIXTURE		1	
- 39	112445	. QUICK DISCONNECT MAKE FROM 680051 MFD BY 80006		1	
- 40	680051	. QUICK DISCONNECT	80006	1	
- 41	117022	. IAR ALLIGNMENT FIXTURE SEE FIG. 20		1	
- 42	116837	. CLAMP, BASE		2	
	SR376L	. . INSERT, SCREW THREAD	83324	1	
	SR250	. . INSERT, SCREW THREAD	83324	4	
	116837-1	. . CLAMP		1	
- 43	117020	. SCREW, T HANDLE		2	
		ATTACHING PARTS			
	MS35338-84	. WASHER		2	
	MS15795-314	. WASHER		2	
		---*---			
- 44	117018	. BLOCK, HINGE		2	
		ATTACHING PARTS			
	MS35249-104	. SCREW		8	
		---*---			
	117167	. SHIM, LOCK, TRANSMITTER RACK		6	
- 45	116833	. PIN		2	
		ATTACHING PARTS			
	MS15795-314	. WASHER		4	
		---*---			
- 46	116834-1	. ARM		1	
- 47	116834-2	. ARM		1	
- 48	116832-1	. PLATE		1	
- 49	116832-2	. PLATE		1	
		ATTACHING PARTS			
	MS35307-38	. SCREW		8	
	MS35338-83	. WASHER		8	
	MS15795-312	. WASHER		8	
		---*---			
- 50	117041	. SUPPORT, STORAGE, ELEVATION YOKE, UPPER		1	
- 51	117043	. SUPPORT, STORAGE, AZIMUTH YOKE, LOWER		1	
		ATTACHING PARTS			
	MS35307-38	. SCREW		4	
	MS35338-83	. WASHER		4	
	MS15795-312	. WASHER		4	
		---*---			
- 52	117179	. BRACKET		1	
		ATTACHING PARTS			
	MS35307-38	. SCREW		2	
	MS35337-83	. WASHER		2	
	MS15795-312	. WASHER		2	
		---*---			
- 53	117039	. PLATE, GUIDE, STORAGE, REFLECTOR		1	
		ATTACHING PARTS			
	MS35307-39	. SCREW		2	
	MS35338-83	. WASHER		2	
	MS15795-312	. WASHER		2	
		---*---			
- 54	1730402	. CHAIR CFE	49671	1	
- 55	1730404	. STOOL, DRAFTING CFE	49671	1	
	116217	. SWITCH, FOOT		1	
- 56	642S	. . SWITCH, FOOT	97918	1	
	116441	. . CABLE ASSY, SPECIAL PURPOSE		1	
- 57	31008	. . . TERMINAL	00779	2	
- 58	RWK-6-3-24C3/8	. . . CONNECTOR, PLUG	71468	1	
- 59	CO-02HOE-/2/18/-0380	. . . CABLE		AR	
- 60	1396027	. HEADSET H-230/U CFE	49671	2	
- 61	8744491	. CABLE ASSY CFE	49671	2	
- 62	117153	. CLAMP, AZIMUTH HORN SUPPORT		1	
		ATTACHING PARTS			
	MS35308-8	. SCREW		2	
	MS15795-310	. WASHER		2	
		---*---			
- 63	117154	. PLATE, MTG, AZIMUTH HORN SUPPORT		1	
		ATTACHING PARTS			
	MS35307-8	. SCREW		4	
	MS35338-82	. WASHER		4	
	MS15795-310	. WASHER		4	
		---*---			
- 64	117155	. PLATE, AZIMUTH HORN SUPPORT		1	
		ATTACHING PARTS			
	MS35307-38	. SCREW		2	
	MS35338-83	. WASHER		2	
	MS15795-312	. WASHER		2	
		---*---			
	KNH420	. . INSERT, SCREW THREAD	98004	4	
- 65	1730449	. HANDSET CFE	49671	1	

FIG. AND INDEX NO.	MFR PART NUMBER	1 2 3 4 5 6 7 8 9 DESCRIPTION	MFR CODE	UNITS PER ASSY	USABLE ON CODE
1 - 66	1730450	. HANGER CFE	49671	1	
		ATTACHING PARTS			
	MS35233-31	. SCREW		4	
	MS35338-79	. WASHER		4	
	MS15795-308	. WASHER		4	
	MS15795-305	. WASHER		4	
		---*---			
- 67	1730444	. KEYBOX CFE	49671	1	
- 68	117077	. PLATE, MOUNTING, KEY BOX ASSY		1	
		ATTACHING PARTS			
	MS35307-38	. SCREW		2	
	MS35338-83	. WASHER		2	
	MS15795-312	. WASHER		2	
		---*---			
- 69	116193	. CONTROL COMMUNICATIONS SEE FIG. 5.		1	
		ATTACHING PARTS			
	MS35249-52	. SCREW		8	
		---*---			
- 70	1730443	. HANDSET CFE	49671	1	
- 71	1730438	. RECEIVER TRANSMITTER CFE	49671	1	
- 72	1730490	. TRAY, MOUNTING CFE	49671	1	
		ATTACHING PARTS			
	AN507C/032-8	. SCREW		6	
		---*---			
- 73	116124	. RACER MOUNT SEE FIG. 18		1	
- 74	117140	. PLATE, RACER MOUNT		1	
		ATTACHING PARTS			
	MS35307-38	. SCREW		6	
	MS35338-83	. WASHER		6	
	MS15795-312	. WASHER		6	
		---*---			
	117142	. . RACER, RACER RACK		1	
	117117	. . GUIDE, RACER RACK		1	
	117141	. . RACER, RACER RACK		1	
		ATTACHING PARTS			
	MS35249-88	. . SCREW		22	
		---*---			
	117138	. . PLATE, UPPER MOUNTING, RACER		1	
	117143	. STOP		2	
		ATTACHING PARTS			
	MS35249-52	. SCREW		2	
		---*---			
	NAS1394C-08L	. . INSERT, SCREW THREAD		1	
	117143-1	. . BLOCK		1	
- 75	6645-526-9476	. CLOCK CFE	80067	1	
		ATTACHING PARTS			
	MS35233-48	. SCREW		3	
	MS35338-80	. WASHER		3	
	MS15795-307	. WASHER		3	
		---*---			
- 76	1730467	. FIRE EXTINGUISHER CFE	49671	1	
- 77	1730471	. BRACKET, FIRE EXTINGUISHER CFE	49671	1	
		ATTACHING PARTS			
	MS35233-28	. SCREW		4	
	MS35338-79	. WASHER		4	
		---*---			
- 78	116566	. BRACKET, INDICATOR SUPPORT		1	
		ATTACHING PARTS			
	MS35307-36	. SCREW		4	
	MS35338-83	. WASHER		4	
	MS15795-312	. WASHER		4	
		---*---			
	NO. 6AD,	. . END RING, BEAD CHAIN BRASS, NICKEL PLATED	70892	2	
	NO. 6	. . CHAIN, BEAD, BRASS, NICKEL PLATED	70892	AR	
	C-304-00CR	. . HOLDER	99378	1	
	116673-4	. . RETAINER, BOLT		2	
	116673-14	. . . TAB		1	
	L6TAV	. . . LANYARD	84256	1	
	MS35338-82	. . WASHER		2	
	116855-1	. . SCREW, CAPTIVE MAKE FROM MS35307-7		2	
- 79	MS35233-14	. SCREW		1	
- 80	NAS1021C04	. NUT		1	
- 81	116703	. CURTAIN, BLACKOUT		1	
- 82	116112	. WORK BENCH SEE FIG. 7		1	
		ATTACHING PARTS			
	MS35308-5	. SCREW		9	
	MS15795-310	. WASHER		9	

TABLE 1 (Continued)

FIG. AND INDEX NO.	MFR PART NUMBER	1 2 3 4 5 6 7 8 9 DESCRIPTION	MFR CODE	UNITS PER ASSY	USABLE ON CODE
		---*---			
1 - 83	1730480	. FRAMC. RELAY CFE	46971	1	
		ATTACHING PARTS			
	MS35307-5	. SCREW		6	
	MS15795-310	. WASHER		6	
		---*---			
	116198	. MOUNT. LANOLINE CONTROL BOX		1	
		ATTACHING PARTS			
	MS35307-39	. SCREW		2	
	MS35249-107	. SCREW		2	
	MS35338-83	. WASHER		2	
	MS15795-312	. WASHER		2	
		---*---			
- 84	KNML420	. . INSERT. SCREW THREAD	98004	6	
- 85	116198-1	. . MOUNT		1	
	117171	. BRACKET. SHOCK MOUNT. COMMUNICATIONS CABINET		1	
		ATTACHING PARTS			
	MS35307-38	. SCREW		3	
	MS35338-83	. WASHER		3	
	MS15795312	. WASHER		3	
		---*---			
- 86	C1050-4	. . MOUNT	81860	2	
		ATTACHING PARTS			
	MS35276-63	. . SCREW		8	
	MS35338-81	. . WASHER		8	
	MS15795-308	. . WASHER		16	
	MS35650-104	. . NUT		8	
		---*---			
- 87	117170	. . BRACKET. SUPPORT. COMMUNICATIONS CABINET		1	
- 88	MS35307-12	. SCREW		2	
- 89	MS35338-82	. WASHER		2	
- 90	116118	. UHF VHF RADIO SET GROUP SEE FIG. 2		1	
		ATTACHING PARTS			
	MS35307-13	. SCREW		4	
	MS35338-82	. WASHER		4	
	MS15795-310	. WASHER		4	
		---*---			
- 91	1730955	. POWER CABLE CFE	49671	1	
- 92	1730463	. RADIO SET GROUP CFE	49671	1	
- 93	1730462	. RADIO SET GROUP CFE	46971	1	
- 9A	1730776	. WAVEGUIDE CFE	46971	1	
- 95	1730956	. POWER CABLE CFE	46971	1	
- 96	1730932	. VIDEO CABLE CFE	46971	1	
- 97	1730929	. VIDEO CABLE CFE	46971	1	
- 98	1730926	. VIDEO CABLE KIT CFE	46971	1	
- 99	116200	. TRANSPORT TIE DOWN KIT SEE FIG. 19		1	
-100	117190	. BOX. STORAGE. MISCELANIOUS		1	
	H322-3-1	. . GROMMET		3	
	H323-3-1-1	. . PLUNGER		3	
	116673-1	. . RETAINER. BOLT		4	
	L6T4V	. . . LANYARD		1	
	116673-11	. . . TAB		1	
-101	116102	S-270/TPN-14 ELECTRICAL EQUIPMENT SHELTER SEE FIG. 9		1	

SECTION 2

THE SPECIFICATION, MIL-R-27921 (USAF)

2.0 This section covers suggested changes to the AN/TPN-14 specification, and is divided into three main subsections, according to the nature of the suggested changes. The first, 2.1, deals with those areas which, in the writer's opinion, would benefit from a change of approach in specifying equipment characteristics. The second, 2.2, covers those portions where the approach is deemed satisfactory but where the intent of the specification would be more fully realized by a different manner of stating the required parameters. The third, 2.3, includes those sections where it is felt that too much design detail is included in the specification; this in effect places the customer in the position of having designed in detail an appreciable portion of the system, and places too many restrictions on the equipment supplier. All paragraph numbers are referred to MIL-R-27921 unless otherwise stated. Appendix 1 contains those paragraphs of MIL-R-27921 to which reference is made in this section.

2.1 APPROACH. This subsection covers those paragraphs in the equipment specification where it is felt that improvement would result from a different approach in specifying the desired characteristics.

2.1.1 Radar Transmitter Power. In paragraph 3.5.5.4, it would be preferable to specify the desired range and beamwidth to be achieved, rather than transmitter power, since the obtainable range is dependent on several other factors, including antenna and receiver gains, receiver noise figure, and waveguide losses.

2.1.2 Microwave Transmitter Power. With regard to specification paragraph 3.5.10.3.1.4, the comments of paragraph 2.1.1, above, also apply.

2.1.3 Microwave Parabolic Antenna. The situation here ties indirectly with that of 2.1.2, above; it is almost necessary, and considerably safer, to specify system performance, rather than that of individual components. In paragraph 3.5.10.3.15, it is inadequate to specify "a minimum of attenuation of the microwave signal" by the connecting waveguide; neither should the antenna diameter be given in this specification. In these respects, the desired operating range and beamwidth of the complete microwave system should be specified.

2.1.4 Communications Power Output. Rather than specifying transmitter power, as is done in paragraphs 3.5.13.1.3 and 3.5.13.2.10, and separately specifying receiver sensitivity and other parameters, it would be preferable to specify overall communication system range and performance.

2.1.5 Duct Insulation. In paragraph 3.5.15.6.5.2, rather than calling for 0.5 inch "nominal" (an indefinite word which should never be used in a specification) thickness of insulation of unspecified characteristics, it would be advisable to specify the maximum BTU loss due to the connecting duct.

2.1.6 Generator. It is realized that a gas turbine powered generator is specified due to lightness of its weight, but in paragraph 3.5.16 it would seem desirable to specify the characteristics desired, including those of logistics, and allow the contractor to make the choice, subject to AF approval.

2.2 PARAMETER DESCRIPTION. In this subsection are discussed those paragraphs where it is felt that the intent of the specification would be more fully realized by a different manner of stating the required parameters. In some cases, this is simply a matter of phrasing the requirements more carefully, in order to eliminate loopholes.

2.2.1 Arrangement of Components. In paragraph 3.4.5, to specify "readily accessible" and "easily removable" is too vague; it would be preferable to specify a maximum number and complexity of tools, and a maximum time for removal and replacement.

2.2.2 Climatic Conditions, Operating. A tolerance, such as $\pm 3^\circ$, should be applied to those adjustment temperatures specified in paragraph 3.4.11.2(a); this would prevent a good deal of wrangling at the time of testing, since it is impossible to stabilize a piece of equipment precisely at a given temperature. The general principle of specifying a range or tolerance for any quantity or parameter requiring measurement is an essential element in any specification.

2.2.3 Rain and Snow. It is felt that a more realistic test would result if the shelter were subjected to the conditions of paragraph 3.4.11.2.3 with the shelter doors shut. Also, it would be difficult for the customer to prove degradation in performance under the existing specification if the only evidence were a slight leakage of water into the shelter; during the actual environmental tests, there was water leakage into the shelter, and this is deemed undesirable. It would be well to specify additionally that there shall be no such leakage.

2.2.4 Shock. It is somewhat redundant to specify the conditions of both paragraphs 3.4.12.1 and 3.4.12.3.1; it would be preferable to equate the humping at 8 mph to longitudinal and/or lateral shock, and require performance of one test. This would be considerably more precise and controllable, as may be deduced from consideration of the results of the actual hump tests on the PAR in early December 1963, when it was necessary to perform the test again because the correct velocity was not attained during the first test. Refer to paragraph 3.1.2 of this report for details on this test.

2.2.5 Vibration. Here, too, it would be appreciably more precise to specify, in paragraph 3.4.12.3.2, that the equipment be subjected to a specific range and duration of vibration frequencies, with emphasis on resonant frequencies if such are observed, than to call for transport in an unspecified type of vehicle over an unspecified gravel road. For the actual test conducted on the PAR, it proved very difficult to reach an agreement between the supplier and the customer as to what constituted a satisfactory gravel road for this test, simply because there is no specification listed.

2.2.6 Electrical Conditions. The voltage and frequency tolerances given in paragraph 3.4.13 are very desirable goals for the generator output, but are a bit unrealistic as limits to apply to the range of PAR operation; if these ranges are all that is required in this area, and if the system is designed on the basis of having a power supply with only this variation, then it would require only a slight maladjustment of generator output to put the PAR out of commission. A more realistic design range would be 380 to 420 cps, and ±10% on the voltage.

2.2.7 Service Life. The requirements of paragraph 3.4.14 are inconsistent with those of paragraph 3.4.2.3; the latter specifies a life of 20,000 hours, while the former requires operation for 83,000 hours (based on seven days per week of operation; if only five days per week are required, it amounts to 60,000 hours).

2.2.8 Test Points. In paragraph 3.4.22, it would be well to define which waveforms and voltages are considered essential. Terminals should not be used as test points; not only can this be dangerous to personnel, but damage to the equipment may result from careless probing.

2.2.9 Azimuth Positioning. There is a high degree of redundancy between paragraphs 3.5.1.8 and 3.5.1.11; both paragraphs are not necessary.

2.2.10 Target Reflectors. A specification should be included in paragraph 3.5.8 describing the variation of soil types into which the bases will be required to be driven. Noticeable damage was suffered by reflector bases at Edwards AFB because they would not stand up under the pounding required to drive them into the concrete-like soil of the dry lake bed.

2.2.11 Waveguide. In order to avoid misinterpretation, it would be well to specify in paragraphs 3.5.10.3.15.4.2 and 3.5.10.3.15.4.3 that the 15 psi is an internal gage pressure.

2.2.12 Communications and Intercommunications. With respect to paragraphs 3.5.13 and 3.5.13.3.1, specifying RACEP equipment, as well as paragraphs 3.5.13.1, 3.5.13.1.7, 3.5.13.2, and 3.5.13.2.17 which call for specific UHF and VHF transceivers and antennae, it is deemed inadvisable to specify particular items of equipment by the manufacturer's part number, even when a detailed description of the equipment characteristics is included. All too often, the contractor is inclined to supply the named item without being unduly concerned about ensuring that conformance exists to the accompanying described characteristics, and the customer often has considerable difficulty in obtaining such conformance.

A preferable course of action would be simply to describe the item in adequate detail (very little more information would be required than what is already included in this specification, in these particular cases), eliminating any direct reference to the manufacturer's designation, or to generate a "Purchased Part Drawing" or other specification, which would include the manufacturer's part number as well as all important characteristics, and include the stipulation that no equipment is to be delivered (when ordered by the customer's part number on this drawing) unless all stated parameters are met.

2.2.13 Air Conditioner. Here in paragraph 3.5.15.1, as was suggested in 2.2.6, above, it would be advisable to require that the air conditioner operate over a line voltage range of ±10%; this is not an unusually stringent requirement and would ensure greater operating flexibility and reliability.

2.2.14 Air Conditioner Ducts. In paragraph 3.5.15.6.5.1, it is recommended that sealing of the end connections against water leakage also be specified. An air seal which would permit a negligible amount of air to escape, from the standpoint of heating or cooling loss, could admit considerable water under adverse weather conditions. It is even possible for water to seep through what is normally considered an airtight seal.

2.2.15 Accessibility. Here in the air conditioner, just as in the PAR equipment, the phrase "easily removed" of paragraph 3.5.15.12.2 is sufficiently unprecise to allow adverse interpretation by the supplier. A maximum tool complement and times for removal and replacement should be specified.

2.2.16 Clock. In paragraph 3.5.18.2, it is suggested that the last sentence be modified to read, in part" . . . where it can be viewed and the time of day determined by a man seated at the Az-El indicator under any conditions of operation and internal lighting available in the PAR shelter." At present, the specification allows the existence of a non-illuminated clock, and it is practically impossible for an operator to determine the time while conducting an approach operation with low-intensity internal lighting.

2.2.17 Flight Tests. In paragraph 4.3.2.3, the following two modifications are suggested: (1) include a list of aircraft types considered appropriate for the conduct of these flight tests, since there is considerable difference of opinion as to just what target area is presented by any given aircraft, and these opinions may vary by a factor of as much as 5:1; and (2) specify that the results of these tests are to be used as the criteria for determining whether or not there is conformance to the specified antenna patterns. The present specification requires merely that the flight tests be conducted and the data plotted.

2.2.18 Operational Data and Test Reports. The submission of data and reports, as required by paragraphs 4.3.2.7 and 4.3.2.8, has been notably lax on this program; no operational data as specified was available until months after qualification tests were completed, and qualification tests reports were submitted at the earliest, some three months after test completion, rather than the 20 days specified. It is suggested that, in future contracts, the stipulation be made that the disbursement of funds will cease if such prescribed schedules of submission are not met; this should apply similarly to the submission and approval of test plans sufficiently prior to the actual conduct of the tests.

2.3 DESIGN DETAIL. The subsection includes comments on those areas wherein it is felt that too much design detail has been included in this specification; this has the effect of placing an excessive burden, both in the writing of the specification and in the monitoring of the equipment, on the Air Force, and of placing too much restriction on the equipment supplier. Under these conditions, the manufacturer may often be restrained from including parts and techniques which could result in a better performing and less expensive equipment.

2.3.1 Antenna Construction. The requirement in paragraphs 3.5.1.2 and 3.5.2.2 that the antennae be constructed from "epoxy laminate honeycomb fiberglass" effectively prevents the supplier from using alternate materials and techniques even if he knows them to be superior to those specified. If identical parts from a previously designed system are to be used, then there is a definite advantage in time and cost, but such was not the case here.

2.3.2 Mechanical Dimensions. The placing of dimensional limitations on the antennae, as in paragraphs 3.5.1.12 and 3.5.2.11, again may serve to restrict the designer in his attempts to achieve the desired performance characteristics.

2.3.3 Antenna Position Indicator. Once again, in paragraph 3.5.2.10, the writer of the specification is, in effect, telling the equipment specialist how to do his job, placing an undue burden on both people.

2.3.4 Unblanking Pulse. It is possible, for instance, that the use of a resolver voltage (rectified) or potentiometer voltage to bias a multivibrator circuit would prove to be a more reliable manner of generating the DC gate specified than the microswitch circuit described in paragraph 3.5.39. But if it were, the present wording of the specification would prevent its use.

2.3.5 Transmitter-Receiver Dimensions. Restricting the size of the package containing a particular area of circuitry, such as is done in paragraph 3.5.4.3, may also serve to restrict the ultimate performance of the unit due to such restrictions as undesirable crowding of sensitive and/or high voltage parts. The size of the Transmitter-Receiver cabinet is not so critical that it could not be a few inches larger in this application, if necessary. As it happens, the packaging is rather tight in this unit, and on one occasion, interference was noted between the modulator chassis and the main power switch; the results were rather noisy when power was applied.

2.3.6 Radar Transmitter. In paragraphs 3.5.5, 3.5.5.1, 3.5.5.2, and 3.5.5.4, design details are specified which are unimportant in this specification, provided only that the equipment does the job for which it is designed; also, the specifying of many of these parts and parameters will not necessarily, in themselves, achieve the desired results. Even in paragraph 3.5.5.9, specifying the desired range resolution or accuracy would obviate the need for specifying pulse widths, although in this application, they could not vary greatly from those given here. Still, the principle is the same.

2.3.7 Radar Receiver. In this entire section of 3.5.6, considerable effort has gone into listing detailed requirements of individual chassis which could have been left to the equipment designer if only overall performance characteristics were given.

2.3.8 Indicator Group. The description of the time-base sweep in paragraph 3.5.7, that of cursor generation in 3.5.7.3.12, and that of the IF gain controls in paragraph 3.5.7.4.8 - these are all unnecessary if the performance characteristics are specified instead. And in the case of the IF gain controls, those specified do not lend themselves too well to the microwave remote control system, and, in the actual equipment, these controls are telephone-type switches operating motor-driven gain potentiometers.

2.3.9 Paragraph Tabulation. The foregoing paragraphs will serve to illustrate, we believe, the point of the statement in 2.3 above that it is preferable, from a design flexibility standpoint as well as for specification simplicity to specify performance requirements rather than parameter details. And since it will be noticed that the basic statements are of a quite similar nature, the remainder of the paragraphs deemed to fall into this category are simply tabulated below, by number and subject, in order to avoid excessive repetition.

Paragraph Number	Subject
3.5.7.6.11	Control Indicator Dimensions
3.5.10.3.1.1	Microwave Transmitter Klystron Type
3.5.10.3.1.5	Microwave Transmitter waveguide assembly
3.5.10.3.1.7	Video modulation amplifier
3.5.10.3.2	Receiver (all subparagraphs)
3.5.10.3.3	Multiplexer
3.5.10.3.4	Analog data transmitter
3.5.10.3.5	Gate signal converter
3.5.10.3.6	Order wire communications assembly
3.5.10.3.7	Subcarrier transmitters
3.5.10.3.8	Subcarrier receiver
3.5.10.3.9	Tone control receiver
3.5.10.3.10	Tone control transmitter
3.5.10.3.13	Power supply, RF equipment
3.5.10.3.15.3	Antenna radome
3.5.10.3.15.4.2	Waveguides (rigid)
3.5.10.3.15.4.3	Waveguides (flexible)
3.5.10.4.2.1	Propagation reliability (Amend. 3 only)
3.5.10.4.5	Radar Video
3.5.10.4.6	Radar trigger
3.5.10.4.9.1	Tone control reception
3.5.10.4.9.2	Tone control transmission
3.5.12.4	Power connector specifications
3.5.13.1.8	UHF transceiver dimensions
3.5.13.1.9 thru 3.5.13.1.14	UHF transceiver characteristics
3.5.13.2	VHF communications
3.5.13.3	Intershelter communications
3.5.15.7.4	Condenser
3.5.15.7.6	Evaporator
3.5.15.11.4	Power receptacle
3.5.15.11.5	Power cable

SECTION 3

THE EQUIPMENT, AN/TPN-14 PRECISION APPROACH RADAR

3.0 This section covers deficiencies and areas of possible improvement by modification of the equipment. Here, deficiencies are considered to be those areas wherein the equipment fails to meet the requirements of the specification and are discussed in subsection 3.1. Areas of possible improvement in the equipment are discussed in subsection 3.2, and deal with those instances where, although there is no violation of the specification, an improvement in some facet of system operation could be effected. Such improvement, however, is not necessarily always recommended for immediate incorporation.

3.1 EQUIPMENT DEFICIENCIES. In this subsection are discussed those areas wherein there is non-conformance with the stated requirements of the specification. These deviations vary in their degree of seriousness, and for some, early correction is recommended, while for others, further testing is considered necessary. For a few, the recommendation is made to accept the system with the existing condition.

3.1.1 Reliability. MIL-R-27921, paragraph 3.4.2, specifies that the AN/TPN-14 mean time between failure (MTBF) shall conform to the requirements of paragraph 3.2 of MIL-R-26474, which in turn defines a minimum MTBF on the basis of the number of parts contained in the equipment. This is a calculation based on the accumulation of a great deal of empirical data gleaned from many military electronic units and systems, and thus provides one with a reasonably good estimate of probable reliability.

It is generally considered invalid to make a reliability analysis on an operating equipment without at least 1000 hours of operating time. Any less than this provides too small a statistical sample, and the failure rate tends to be higher during the first few hundred hours of operation, particularly on a new piece of equipment. Therefore, the only data available at this time tends to be pessimistically misleading. During 300 hours of operation, while undergoing pattern tests at Edwards AFB, California, there were eight failures, two of which were in the transmitter-receiver. This gives an apparent system MTBF of 42, compared to 94 calculated (for manned operation), and an apparent transmitter-receiver MTBF of 150, compared to a calculated 272. The majority of these failures fall into the category of those which often occur during the initial "debugging" period of equipment operation - areas of marginal operation where a minor circuit redesign or improved part replacement will eliminate the difficulty. This is mentioned, to point out: (1) the danger of using too small a sample for determination of performance characteristics, and (2) that a valid operational reliability analysis must await the completion of qualification and environmental testing and the receipt of the corresponding reports.

Good equipment design, with conservative derating and redundancy where necessary, can effect an improvement in MTBF over a range of 25% to 100%. This is a complex problem, depending on the optimization of several factors, including surface temperature, dissipated power, applied voltage, and ambient temperature. For example, changing the voltage derating on capacitors from 50% to 90% can improve capacitor MTBF by factors ranging between 2:1 and 10:1, depending on the type of capacitor; however, this would serve very little to improve overall unit reliability. One would need also to transistorize tube circuits, derate resistors and redesign transformers, to name a few; then additional cooling might still be necessary, to reduce ambient temperatures below critical values for parts, and this would increase complexity and reduce reliability. And it is to be assumed that a designer of integrity would use deratings of approximately 50% in the initial design. So it can be seen that effecting an appreciable increase in reliability over that calculated in accordance with MIL-T-26474 is not a simple task, and the anticipated increase must be balanced against the probable cost of redesign.

The PAR operated quite well, in general, during its antenna pattern and precision approach tests. The apparent discrepancy between this statement and the short-term MTBF's is explained by the fact that two failures, of which one was a partial failure, occurred right at the end of a day of testing (this is rather unlikely, during 23-hour/day operation), and three others occurred in connection with a turbine generator, wherein switchover to the standby generator was effected immediately. Of the first two mentioned, one was failure of the antenna drive motor at the end of one day, and the other was failure of the wide pulse mode (in the PFN) of the transmitter, noticed after completion of the last flight; these two were repairable during the evening down time. The generator failures included an overtemperature thermostat, a fuel pump, and a faulty cable discovered in reconnecting a repaired generator; in these three cases, the maximum interruption was about one minute, for generator switchover.

3.1.2 Environmental Conditions - Shock. MIL-R-27921, paragraph 3.4.12.3.1, specifies that no mechanical damage and/or degradation shall occur when the PAR is subjected to cross-country rail transportation including humping at 8 mph. During the electrical test on the AN/TPN-14 following the hump test, the radar elevation attenuator (GIB 116369) failed in that the ferrite attenuator strip separated and fell into the waveguide, causing noticeable arcing. This failure was attributed to the excessive shock to which the PAR was subjected during the initial hump test conducted on December 3, 1963, wherein two impacts were sustained, one at 3.3 mph and one at 12 mph. In the second test, conducted December 11, 1963, the equipment was subjected to impact at the required 8 mph, and it was during the electrical post-shock test that the above failure occurred. It was noted in Gilfillan's Shock Test report that the Drop Test was performed on the same subsystem on December 5 and the Rain Test on December 7, and that electrical performance was normal after each of these tests.

While it is true that the equipment was overtested by a factor of 2 1/4, it is worthy of note that no other units or parts were noted to have suffered any damage. The shock in this case is conservatively estimated to be 100 g, or more, and it is reasonable to expect several parts to fail when subjected to this order of shock. It is possible that this was a one-time failure, due to faulty manufacture and quality control on this individual assembly, but this is something that should be determined. It is recommended that the waveguide assembly (GIB 116369), only, be subjected to the required shock; this can be done easily on a small fixture, available at many electronics manufacturing plants and testing laboratories. It would be preferable to test an assembly from one of the other AN/TPN-14 systems, and to subject it to a minimum of three shocks. In the event of failure, it would be necessary to encourage the vendor to improve the attenuator design, using a more durable ferrite strip and method of assembly. And in the event of success, the environmental test report (RCA's No. TR14E-10) could be accepted with confidence.

3.1.3 Acoustic Noise Level. The acoustic noise level in the PAR shelter is required by paragraph 3.4.25 of MIL-R-27921 to be not more than 75 db above the ASA standard reference level of 0.0002 dynes/cm^2 along a line forming the geometric axis of the shelter. Human factors studies have determined that this is the maximum noise level endurable with reasonable comfort over any sustained period, and the maximum practical level at which to operate communications gear. Beyond this, if a noise level of 85 db obtains, it may result in ear damage and hearing loss.

The noise level here exceeded specification limits, having been measured at 86 db. The major contribution is being made by the UHF and UHF transceivers, with their cooling blowers. This is not too surprising, considering the small size and high speed of the blower (it literally screams). We recommend a blower of larger diameter and slower speed, with the same or greater cooling (cfm) capacity. This would necessitate some minor chassis modification, but this would be a small price to pay for the reduction in operator strain and fatigue and the resultant increase in efficiency.

3.1.4 Shelter. The PAR equipment shelter is required by MIL-R-27921, paragraph 3.5.11, to conform to the requirements of MIL-S-52059. There are strong indications that these requirements are not being met, in that extensive delamination of the walls has occurred on all shelters. Paragraph 3.2.2.3 of MIL-S-52059 specifies that "no separation of laminations shall occur due to rapid temperature changes". Unfortunately, "rapid" is undefined, and there is no stated condition other than temperature under which delamination is prohibited; this makes it rather difficult, from a literal standpoint, to prove that excessive delamination exists. However, it is evident that freedom from delamination is desired, and it is evident that delamination does exist.

Out recommendation here is twofold: (1) change MIL-R-27921 to specify a maximum percentage of total delaminated area, such as 20%, and a maximum size of any one "spot" or area of separation, such as 1 square foot (it would be preferable to make the equivalent or greater modification in MIL-S-52059, but it is realized that this would likely be a tedious and lengthy process); and (2) have the supplier effect repairs at least on all those shelters where any panel has suffered delamination over more than 30% of its total area or has individual delaminated areas of more than two square feet in area (a panel would be defined as any surface area on one side of the shelter which is secured along its perimeter by mechanical means such as bolts, rivets or welding, as opposed to chemical bonding with cement). The figures of 20% and 1 square foot are not from any strength calculations, but are an engineering judgement based on observations and experience, and are recommended as limits for future shelters. The figures of 30% and two square feet are considered a practical compromise between what is desired and what actually exists on several shelters at present.

3.1.5 Pulse Repetition Frequency. Paragraph 3.5.5.8 of MIL-R-27921 requires that "The pulse repetition frequency shall be 1200 pulses per second. The trigger frequency shall not be derived from the 400 cycle power source." At present, the PRF is synchronized with the 400-cps power frequency, as the most practical solution to the problem of a low-frequency (approximately 20-cps) beat note which was observed on the power lines during checkout tests in August 1963, at Gilfillan's Fontana site.

The frequency tolerance on the PRF generator is ±5%, and that on the power generator is ±2%. There was a high probability that these generators would not operate on exactly the same frequency, and when they did not, a resultant beat frequency was observable on the power lines. This apparently fed back into the frequency regulator and caused hunting of the power generator. To proceed with the flight tests of the AN/TPN-14, permission was given for temporary synchronization of the PRF with the power frequency, with the understanding that a subsequent correction of the above condition would be made.

In addition to the specification requirement, the AFCS position is that they are not in favor of the present PRF synchronization because "the PRF would become unstable with any frequency fluctuation of the power source". This latter objection is a true statement, but only to the extent that the power source, itself, would be unstable. Any normal variation of the power generator frequency within the specification limits would cause only a corresponding variation in the PRF, and this is not such an amount that would normally be termed an instability. Also, such a variation would be tolerable by the transmitter, and it is highly unlikely that it would even be noticeable to the PAR operator; the variation in the number of hits (by individual pulses) per target would be negligible. With any appreciable power frequency variation outside the normal limits, particularly on the low side, the entire equipment would probably cease operation, and PRF stability would be irrelevant.

The primary requirement for an extremely stable PRF would be for the use of MTI, particularly with the narrow pulse widths used in a PAR; however, this system does not have MTI. If these and/or future systems are modified to include MTI operation, it would be necessary to incorporate an independent stable PRF generator. However, the original problem of a low-frequency beat would still exist, and it would be necessary to find an alternate solution to the problem. Two possible courses of action in this case would be: (1) to install high-pass filters on the transmitter power lines, or (2) change the PRF to, for example, 1400 cps to give maximum separation of the PRF and the third and fourth power frequency harmonics. This should be beyond the operating range of the frequency regulator. A PRF of 1400 would reduce the maximum range to 59 miles; even with "dead time" allowance, this is still much more than required, and thus gives no cause for concern.

PAR operation, to date, has been quite satisfactory in this respect, and our recommendation is to leave the PRF synchronized with the power frequency at least for these first three AN/TPN-14 systems unless MTI is later incorporated; then a course of action, such as outlined above, would be necessary.

3.1.6 Assembly-Disassembly. Paragraph 4.3.2.2 of MIL-R-27921 requires that neither assembly nor disassembly of the PAR, from transport to operating condition, or vice versa, shall require more than one hour by three men. These men shall be (equivalent to) one AF skill level 7 and two AF skill level 5. The results of an assembly-disassembly test at Ft. Devens, Mass., on November 7, 1963, indicate that this requirement is unlikely to be met; disassembly required nearly 5-1/2 hours, and assembly required over 2-1/2 hours.

It is assumed that, in a normal system deployment, experienced personnel would be performing this task. The men involved in the above test had never been through the procedure, and it will be realized that this slowed them down somewhat. It is impossible to conclude at this time how much improvement may be realized by trained personnel; a rough estimate is a 20% to 40% reduction in the above times. It is unlikely that the 1-hour goal will be achieved, due in part to other specification requirements. Paragraph 3. 5. 11. 22 of the PAR specification requires essentially that all equipment (except generators) external to the shelter be stored inside for transport. This is physically impossible, but Gilfillan has made a good attempt, and has managed to include everything except the air conditioner, the leveling jacks, and a stool. Figures 6a, 6b and 6c show the transport tie down condition, and illustrate rather graphically that internal storage requires an appreciable number of racks and brackets, with a corresponding amount of assembly and disassembly time; this, in turn, saves on storage and transport space and handling. One does not obtain something for nothing.

The breakdown of times required to perform the various tasks, or portions of assembly and disassembly is given below.

Unstowing and Assembly

Task	Time
Unstow equipment from shelter	65 min.
Prepare shelter	7 min.
Mount PAR Antenna	46 min.
Mount Microwave & Comm. Antennae	33 min.
Total	2 hrs. 31 min.

Disassembly and Stowing

Task	Time
Remove Microwave and Comm. Antennae	23 min.
Remove PAR Antenna	40 min.
Internal Securing and Duct Storage	16 min.
Stowing	238 min.
Total	5 hrs. 17 min.

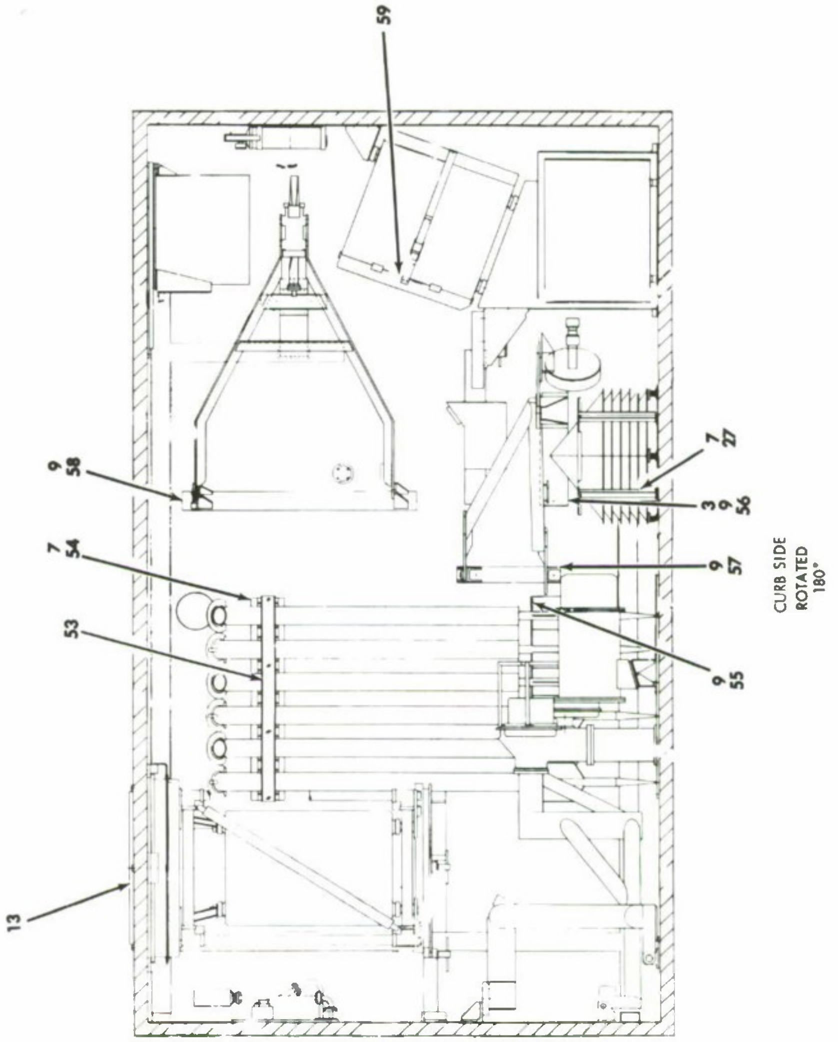

Figure 6A. Transport Tiedown Kit (See Table 2)

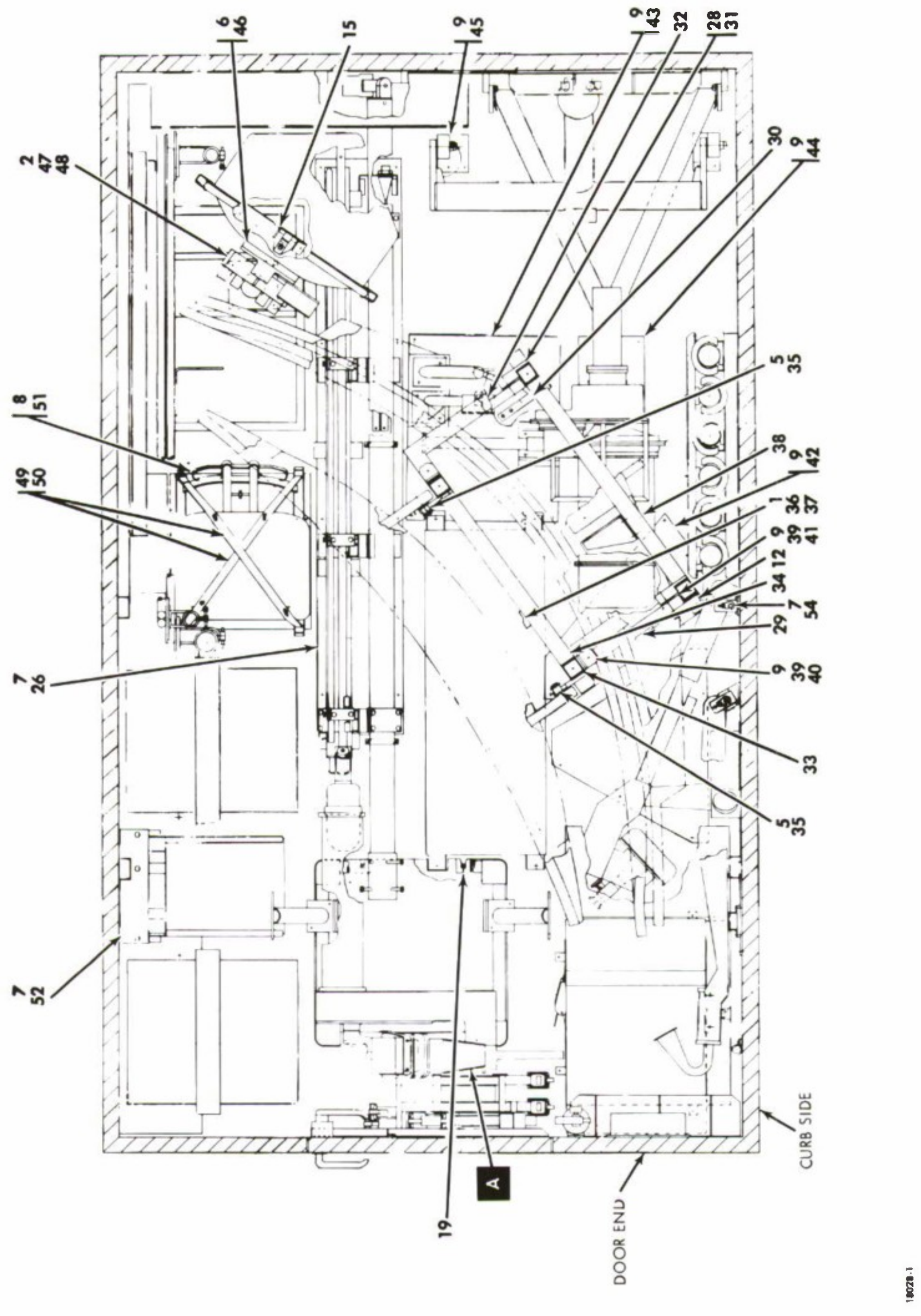

Figure 6B. Transport Tiedown Kit (See Table 2)

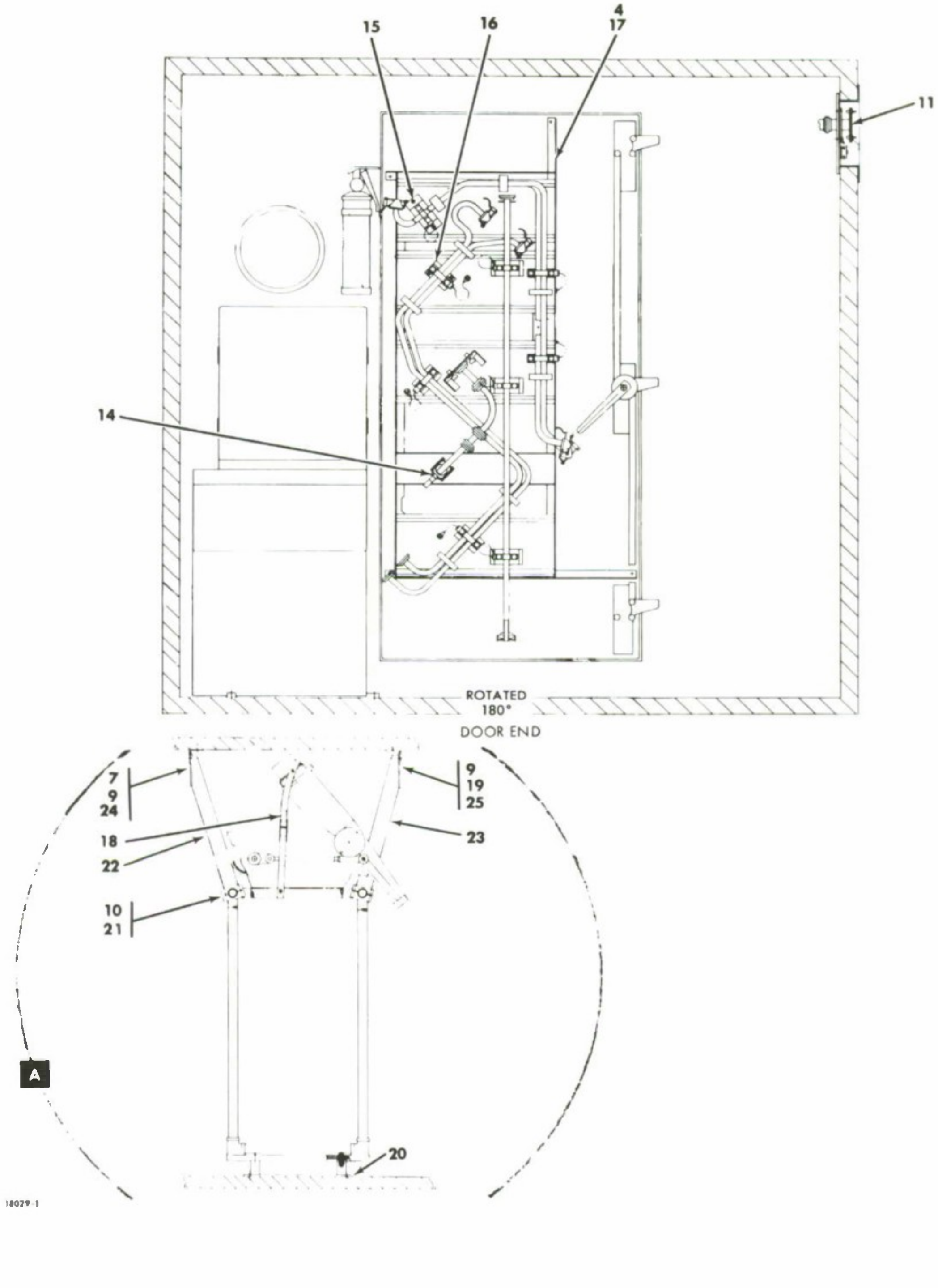

Figure 6C. Transport Tiedown Kit (See Table 2)

TABLE 2

FIG. AND INDEX NO.	MFR PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7 8 9	MFR CODE	UNITS PER ASSY	USABLE ON CODE
19 -	116200	TRANSPORT TIE DOWN KIT SEE FIG. 1 NHA		REF	
- 1	116671-3	. BOLT		1	
		ATTACHING PARTS			
	MS35338-84	. WASHER		1	
		---*---			
- 2	116759-3	. BOLT		4	
- 3	116759-1	. BOLT		1	
		ATTACHING PARTS			
	MS15795-312	. WASHER		5	
		---*---			
- 4	116855-5	. SCREW		5	
- 5	116855-2	. SCREW		2	
- 6	116855-1	. SCREW		2	
		ATTACHING PARTS			
	MS35338-82	. WASHER		9	
		---*---			
- 7	116614-5	. BOLT, CAPTIVE MAKE FROM MS35307-36		21	
- 8	116614-4	. BOLT, CAPTIVE MAKE FROM MS35307-41		4	
- 9	116614-3	. BOLT, CAPTIVE MAKE FROM MS35307-38		33	
- 10	116614-2	. BOLT, CAPTIVE MAKE FROM MS35307-40		4	
		ATTACHING PARTS			
	MS35338-3	. WASHER		62	
		---*---			
- 11	116867	. COVER, BULKHEAD		1	
- 12	117111-4	. BRACKET, STORAGE, ANTENNA		4	
		ATTACHING PARTS			
	MS35307-10	. SCREW		8	
	MS35338-82	. WASHER		8	
	MS15795-310	. WASHER		8	
		---*---			
- 13	116397	. COVER ASSY, SHIPPING		1	
- 14	112445	. QUICK DISCONNECT MAKE FROM 680051 MFD BY 80006		1	
- 15	117182	. BRACKET, WAVEGUIDE		1	
- 16	117181	. BRACKET, WAVEGUIDE		1	
		ATTACHING PARTS			
	MS35234-64	. SCREW		2	
	MS35338-81	. WASHER		2	
	MS15795-308	. WASHER		2	
		---*---			
- 17	117177	. RACK, WAVEGUIDE		1	
- 18	NAS1213R10J59	. STRAP		1	
- 19	117034	. BOLT, SHOULDER		2	
- 20	117169	. MOUNT, STORAGE, ANTENNA SUPPORT		1	
- 21	117052	. CLAMP, MOUNT, STORAGE, ANTENNA SUPPORT		2	
- 22	117186	. BRACKET, SUPPORT, STORAGE ANTENNA		1	
- 23	117047	. BRACKET, SUPPORT, STORAGE ANTENNA		1	
- 24	117046-2	. BRACKET, STORAGE, ANTENNA SUPPORT		1	
- 25	117046-1	. BRACKET, STORAGE, ANTENNA SUPPORT		1	
- 26	117173	. MAST STORAGE, MISCELANIOUS EQUIPMENT		1	
- 27	117028	. STORAGE, CORNER, REFLECTOR		1	
- 28	117088	. SUPPORT, STORAGE, AZIMUTH ANTENNA		2	
		ATTACHING PARTS			
	MS35307-10	. SCREW		4	
	MS35338-82	. WASHER		4	
	MS15795-310	. WASHER		4	
		---*---			
- 29	117089-2	. CLAMP, STORAGE, ANTENNA		1	
- 30	117089-1	. CLAMP, STORAGE, ANTENNA		1	
		ATTACHING PARTS			
	MS35307-10	. SCREW		8	
	MS35338-82	. WASHER		8	
	MS15795-310	. WASHER		8	
		---*---			
- 31	117187	. BRACE, STORAGE, ANTENNA		1	
- 32	117091	. BRACE, STORAGE, ANTENNA		1	
- 33	117090	. BRACE, STORAGE, ANTENNA		2	
- 34	117093	. FRAME, STORAGE, ANTENNA, AZIMUTH		1	
- 35	117185	. SUPPORT, PIN		2	
- 36	117087	. NUT, STORAGE, ANTENNA, ELEVATION		1	
		ATTACHING PARTS			
	MS15795-320	. WASHER		1	
	MS35338-88	. WASHER		1	
	MS35690-1030	. NUT		1	
		---*---			
- 37	117085	. BRACKET, STORAGE, ANTENNA, ELEVATION		1	
		ATTACHING PARTS			
	MS35307-8	. SCREW		2	
	MS35338-82	. WASHER		2	
	MS15795-310	. WASHER		2	
		---*---			
- 38	117092	. FRAME, STORAGE, ANTENNA, ELEVATION		1	
- 39	117086	. BRACKET, STORAGE, ANTENNA		4	
		ATTACHING PARTS			
	MS35307-38	. SCREW		8	
	MS35338-83	. WASHER		8	
	MS15795-312	. WASHER		8	
	MS35690-510	. NUT		8	

TABLE 2 (Continued)

FIG. AND INDEX NO.	MFR PART NUMBER	1 2 3 4 5 6 7 8 9 DESCRIPTION	MFR CODE	UNITS PER ASSY	USABLE ON CODE
		---*---			
19 - 40	117108	. ANGLE, STORAGE, ANTENNA, AZIMUTH		1	
- 41	117109	. ANGLE, STORAGE, ANTENNA, ELEVATION		1	
- 42	117102	. PLATE, FLOOR, NO. 2 STORAGE, ANTENNA		1	
- 43	117101	. PLATE, FLOOR, NO. 2 STORAGE, ANTENNA		1	
- 44	117054	. STORAGE, AZIMUTH DRIVE		1	
- 45	117044	. BRACKET, STORAGE, ELEVATION YOKE		1	
- 46	116831	. SUPPORT, STORAGE, MICROWAVE ANTENNA		1	
- 47	116830	. NUT, STORAGE, MICROWAVE ANTENNA		2	
		ATTACHING PARTS			
	MS35233-15	. SCREW		2	
		---*---			
- 48	116809	. HOLDER, ANTENNA STORAGE		1	
- 49	NAS1211G10	. BUCKLE		2	
- 50	NAS1212R10EJ60	. STRAP		2	
- 51	117172	. STORAGE, CHAIR		1	
- 52	117055	. STORAGE, POLARIZER, FRANGIBLE ASSY		1	
- 53	117037	. CLAMP, TARGET REFLECTOR		1	
- 54	117036	. RECEPTACLE, STORAGE, TARGET REFLECTOR		1	
- 55	117038	. ANGLE, STORAGE, TARGET REFLECTOR		1	
- 56	117156	. BRACKET, STORAGE, ELEVATION HORN SUPPORT		1	
- 57	117165	. BRACKET, STORAGE, ELEVATION HORN SUPPORT		1	
- 58	117164	. BRACKET, STORAGE, AZIMUTH HORN SUPPORT		1	
- 59	117175	. COVER, STORAGE, CONTROL INDICATOR		1	

Although it is realized that it is preferable to assume that only that complement of men which is normally assigned to operate the system will be available for assembly and disassembly, it was observed that there are areas of parallel tasks where additional personnel could reduce these times appreciably. Two more men could essentially eliminate the (assembly) times for mounting the microwave and communication antennae, and shelter preparation, since these can be done simultaneously with the mounting of the PAR antenna. Also, these two men would speed the unstowing of equipment from the shelter. Five men seems to be the practical limit here; with a sixth man, it is opined that they would begin to interfere with each other.

There may be puzzlement regarding the nearly 4:1 ratio of times for stowing and unstowing the shelter. Familiarity with these operations, through training, will reduce both the absolute times and the ratio. It is appreciably easier to unstow equipment when, in most cases, there is a limited and fairly obvious choice of which item to remove next. Stowing the same equipment for the first time is not quite as simple, even with the aid of photographs (to which considerable reference was necessary here); the sequence of stowage is not always obvious, but in several instances, there is only one available sequence. Then, too, one must find the right bracket for the part, where in assembly, one may simply set brackets aside, to be stored after operation is achieved.

A fast assembly time will generally be of greater importance than disassembly, and it seems quite probable that total assembly time can easily be less than 2 hours, and may approach 1 1/2 hours. It is unlikely that disassembly for transport will be less than 3 hours. Our conclusion is that while one hour for either operation is a desirable goal, it is unrealistic, particularly in consideration of the internal parts stowage requirement as opposed to external pallet stowage, and there should not be a strong insistence on adherence to this specification requirement.

3.1.7 Antenna Patterns. The cosecanted patterns of the elevation and azimuth antennae are described, respectively, in paragraphs 3.5.1.4 and 3.5.2.4 of MIL-R-27921. The antenna pattern tests described in paragraph 4.3.2.3.2 are intended to demonstrate conformance to the specified pattern requirements. Plots of the data obtained from these tests define patterns as illustrated in figures 7, 8, and 9. In figures 7 and 8, the solid outline defines the theoretical CSC^2 pattern for the azimuth antenna; this is essentially the same for linear and circular polarization. The altitude scale is expanded to give a larger, clearer picture. The data (represented by X's) plotted on these charts from the pattern outline of actual aircraft detection as observed during the flight tests at Edwards AFB. Figure 9 gives a simultaneous picture of cosecanting of the elevation antenna for both left and right of runway.

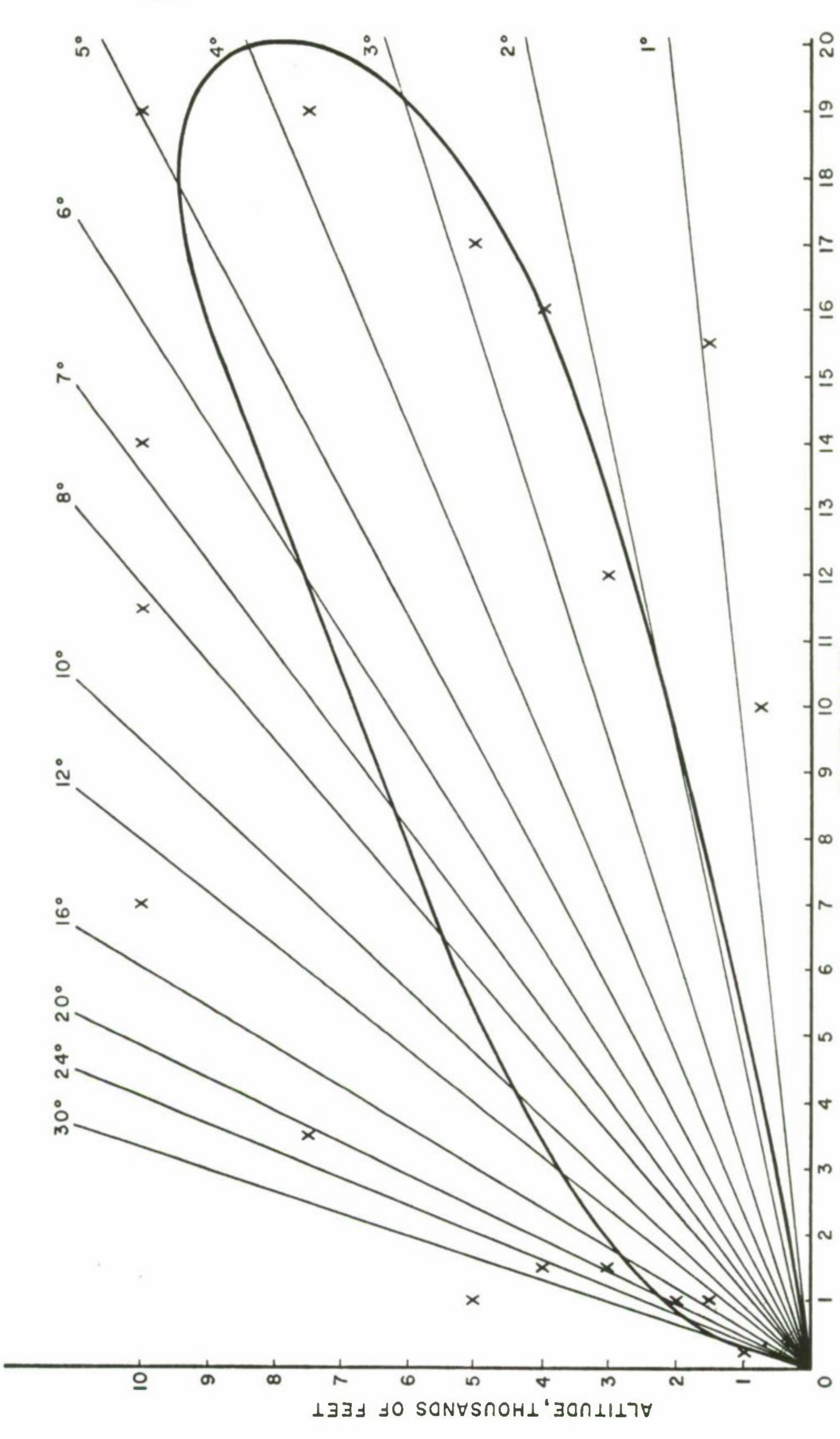

Figure 7. Azimuth Antenna, Vertical Plane, Circular Polarization

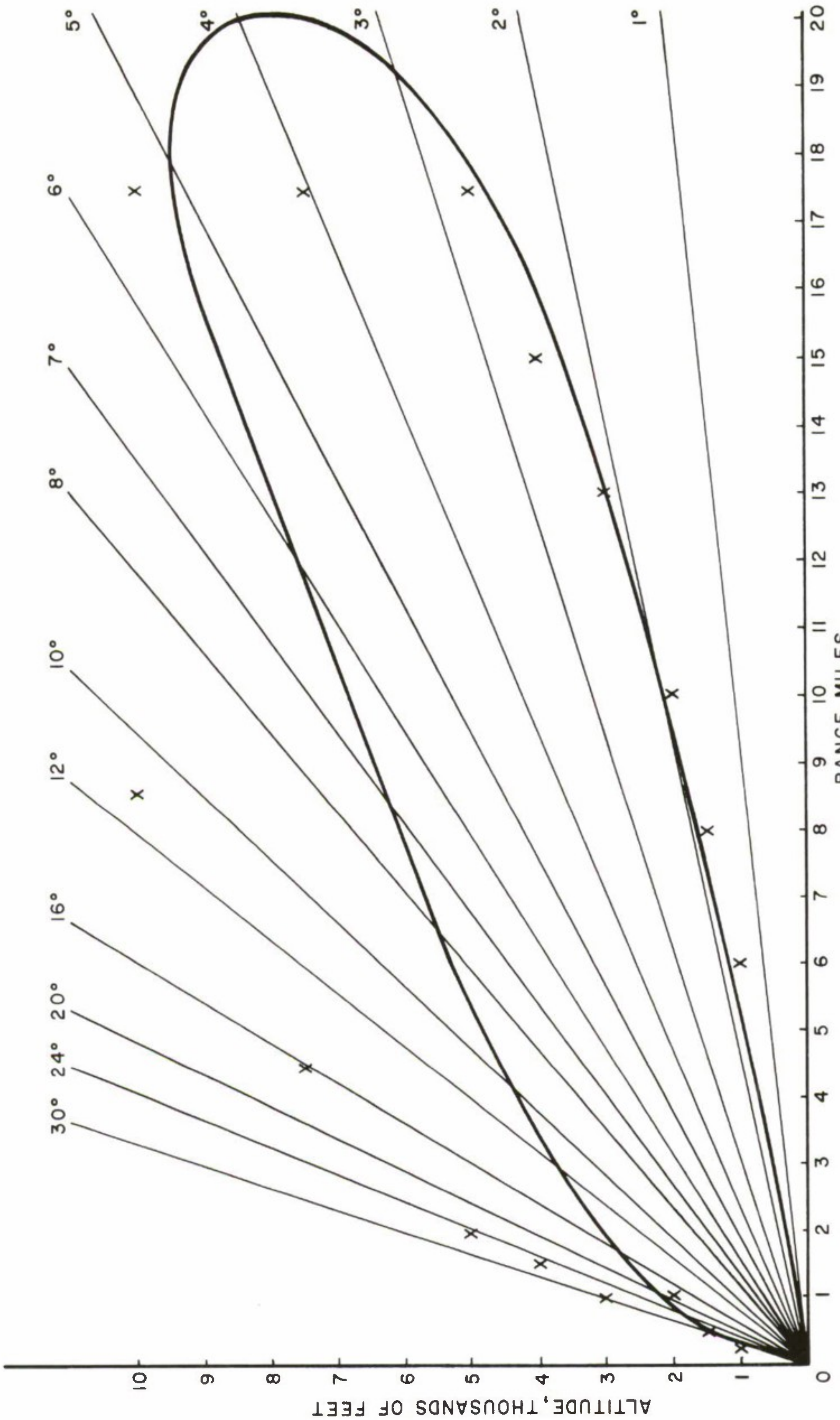

Figure 8. Azimuth Antenna, Vertical Plane, Linear Polarization

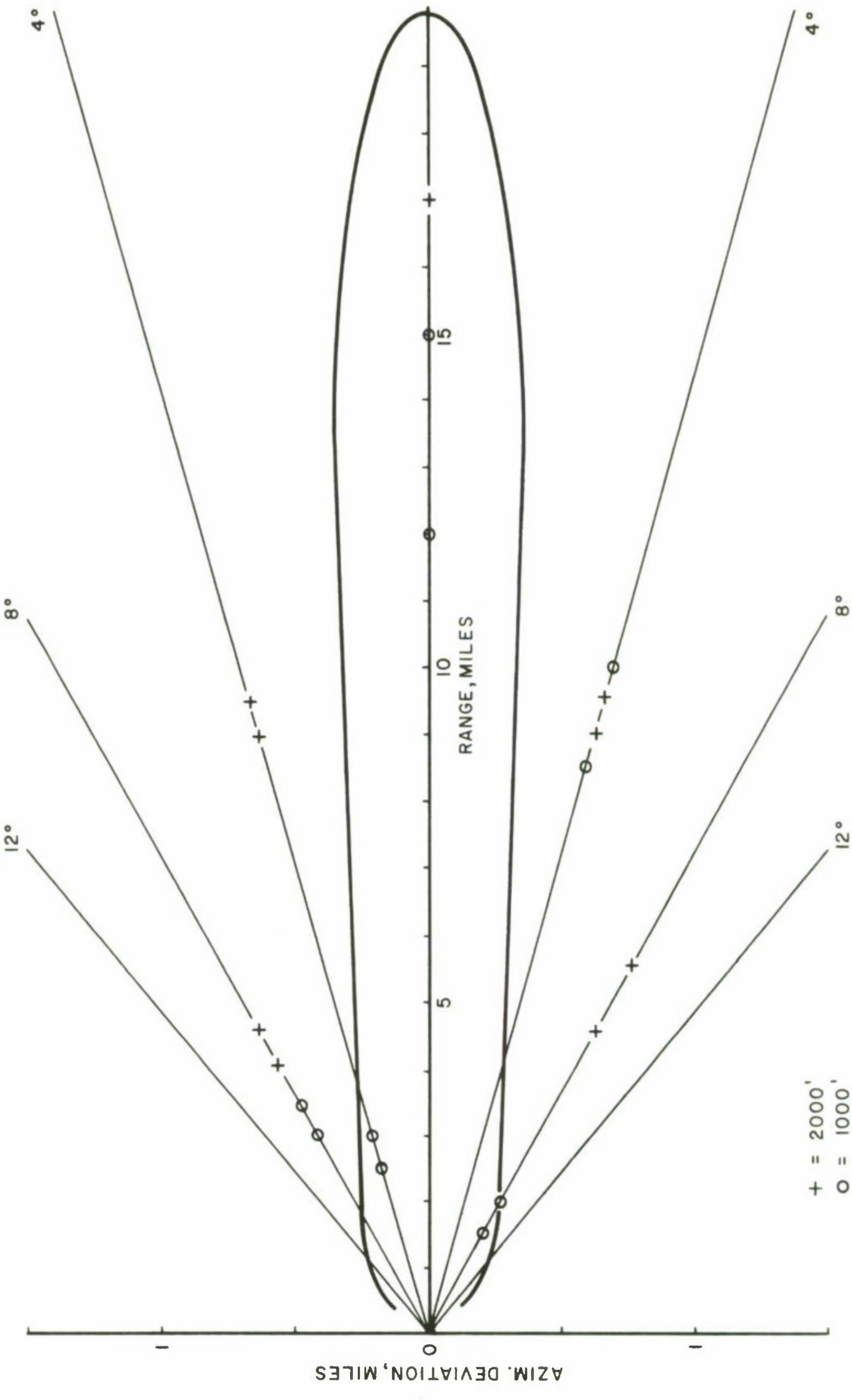

Figure 9. Elevation Antenna, Horizontal Plane, Linear Polarization

In actuality, of course, the condition does not exist as pictured here; cosecanting is possible on only one side at a time, and the presentation is made thusly for simplicity and ease of comparison. The solid outline defines the theoretical pattern, and data are plotted for the outer limits of detection at two altitudes in the range of aircraft altitudes to be expected in the vicinity of an airfield.

It may be seen from figures 7 and 8 that the cosecanting of the azimuth antenna in the vertical plane is nearly in conformance with the specification requirements, while figure 9 illustrates that the cosecanting of the elevation antenna in the horizontal plane fell noticeably short of the goal. These patterns will be discussed in more detail in paragraphs 3. 1. 7. 1 and 3. 1. 7. 2, below. However, one point should be kept in mind; paragraph 4. 3. 2. 3. 2. 2 of the PAR specification requires only that "Antenna propagation charts shall be plotted for both . . . antennas in each mode of operation . . ." There is no specification requirement that these tests shall be the criteria for determining conformance (or lack of it) to the stated pattern requirements of MIL-R-27921. The contractor plans to submit antenna pattern recordings to indicate compliance with the specification requirements.

3. 1. 7. 1 Elevation Antenna Pattern. The horizontal pattern of the cosecanted elevation antenna is described by paragraph 3. 5. 1. 4 of MIL-R-27921: "Under conditions of either right or left of runway cosecanting the appropriate part of the one-way radiation pattern of the antenna shall follow a cosecant-squared curve within plus or minus 1.5 db from the half-power point to not less than 12° as measured from the peak of the main beam." Examination of figure 9 will indicate that this condition does not obtain in typical operating conditions. On the 12-degree radial, there were target returns for left of runway cosecanting only at altitudes of 400 feet and under, and at ranges of less than 2 miles; at 8 and 4 degrees, the pattern approaches the coverage one would expect. Some degree of cosecanting is being realized, but the plate is not nearly as effective as was anticipated; this is probably due to a combination of factors, such as reflector shape and position, and feedhorn position. Correction of this condition would seem to involve a major redesign effort.

3. 1. 7. 2 Azimuth Antenna Pattern. The vertical pattern of the azimuth antenna shall be, according to paragraph 3. 5. 2. 4 of MIL-R-27921, "no greater than 3.5° CSC^2 to plus 30°. The free space pattern from the upper minus 3 db point to plus 24° shall not deviate from the theoretical CSC^2 pattern by more than minus 1 db to plus 3 db when the center of the vertical beam is at an elevation angle of plus 3° to the horizon." Perusal of figures 7 and 8 will indicate that the minimum pattern requirements are very nearly met; only with linear polarization does the pattern fall short, and that on the beam center, by about 1.5 db down from a range of 20 miles, or about 0.5 db short of specification. On the upper side of the beam, the

coverage is considerably in excess of that specified. At first glance, this might seem to be all to the good, but there is an apparently corresponding effect wherein the coverage on the low side of the beam, while meeting the specification, is "thinner" than optimum, in that target returns tended to be of a lesser intensity than for upper beam coverage. A more symmetrical coverage is to be desired, and deserves consideration for any future design.

3.1.7.3 Recommendation. In spite of the fact that horizontal cosecanting of the elevation antenna is considerably short of the design goal, no difficulty was encountered during the several weeks of flight tests at Edwards AFB in August and September of 1963, in conducting approaches in a normal manner. At this location, it was necessary to use the PAR in a search capacity during the downwind leg of the pattern, and this was done without particular difficulty. In view of the acceptable performance to date, and in consideration of the extensive time and cost which would be required for antenna redesign and fabrication, it is our recommendation that these first three PAR systems be accepted with the existing antennae. In the event of the purchase of future systems, particularly if modifications are to be incorporated, strong consideration should be given to correcting the deficiencies noted above.

3.1.8 Control Indicator. The capability of obtaining a sharp focus of the time-base sweep on the indicator CRT is required by paragraph 3.5.6.4.2 of MIL-R-27921. As may be observed in figures 4 and 10 through 15, this capability does not exist; with optimum adjustment of the focus and intensity controls, only approximately 60% of the sweep (cursor) may be brought into reasonably sharp focus. This can be done with optimum focus on either left or right of the CRT.

The normal standard of permissible defocusing is a factor of 2:1 over the optimum beam focusing; on this indicator, the defocusing is in the order of 5:1. There is, however, the fact that the cursors are reasonably well in focus over the more critical portion of the approach path; if the 10-mile scale is used, the last 5 miles to touchdown are in acceptable focus, and on the 5 mile scale, the last 3 miles are clear enough.

This inability to obtain a sharp sweep focus across the entire tube face is annoying, and reduces the accuracy of observations in the defocused area. However, it does not appreciably reduce the operational capabilities of the PAR. If it is desired to eliminate the existing condition, there is the possibility of using dynamic focusing, wherein the deflection voltage is sampled and fed to the focus coil. This would necessitate additional circuitry, with a resultant decrease in reliability, for questionable practical improvement. Our recommendation is to make no changes in the indicator in the first three AN/TPN-14's; if additional systems are to be bought, wherein modifications are to be considered, this would be the point at which to effect an improvement in the CRT focusing. We would suggest, however, that any decision in this latter case be based largely on the reactions of experienced PAR operators after at least several weeks of AN/TPN-14 operation.

3.2 EQUIPMENT MODIFICATIONS. In this subsection are discussed possible modifications to the AN/TPN-14, their probable effects on system operation and performance, and our resultant recommendations.

3.2.1 MTI. There is no specification requirement for MTI (Moving Target Indication) in the AN/TPN-14, but it has been suggested by AF personnel that MTI would be a desirable feature to be incorporated into the system. The consideration here is primarily one of personnel (pilot) safety, in that clutter from the surrounding terrain sometimes obscures portions of the glideslope and to a lesser extent, the courseline, thus making it more difficult for the PAR operator to maintain a track on the target aircraft. This is felt to be particularly serious where the near edge of the clutter is close to the touchdown point (i.e., within 1-1/2 miles), since for any distance appreciably less than this, if the pilot has wandered from the approach path while passing through a zone of clutter, the recovery time becomes uncomfortably, even dangerously, short. These objections are quite valid and deserve serious consideration.

The photographs of figures 10 through 15 were taken at the PAR Control Indicator while the system was located at the airfield of Fort Devens, near Ayer, Massachusetts, in April, 1964. They are included here to illustrate the conditions which gave rise to the suggestion of MTI, and to show the effectiveness of combating clutter with existing modes. At this location, there are two small hills flanking the runway approach from one direction, these being located an estimated 10° on either side, and about one mile beyond the touchdown point. This is thought to be a worse situation than is likely to be encountered at the majority of sites, although at a runway located in a dense jungle area, nearby vegetation would probably provide a similar problem. As may be observed in these photographs, these hills do not give a great interference problem in azimuth, but all this clutter shows up in one solid block in the elevation presentation, interfering with the lower glideslope angles. The abbreviations used in describing the system conditions portrayed in each picture are: CP, Circular Polarization; LP, Linear Polarization; IAR, Increased Angular Resolution; STC, Sensitivity Time Control. All pictures were taken with maximum IF gain; when viewing these, refer to figure 16.

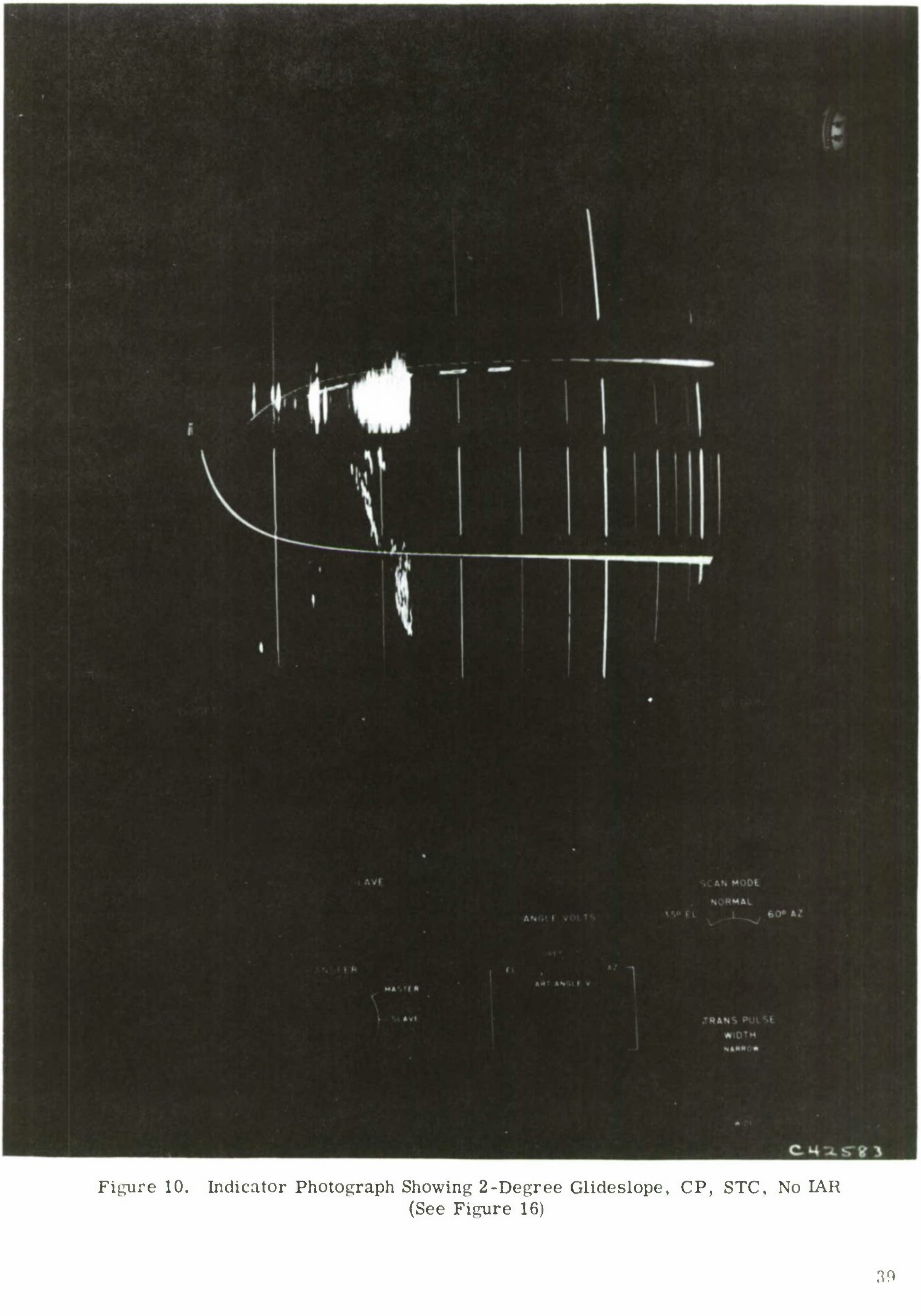

Figure 10. Indicator Photograph Showing 2-Degree Glideslope, CP, STC, No IAR
(See Figure 16)

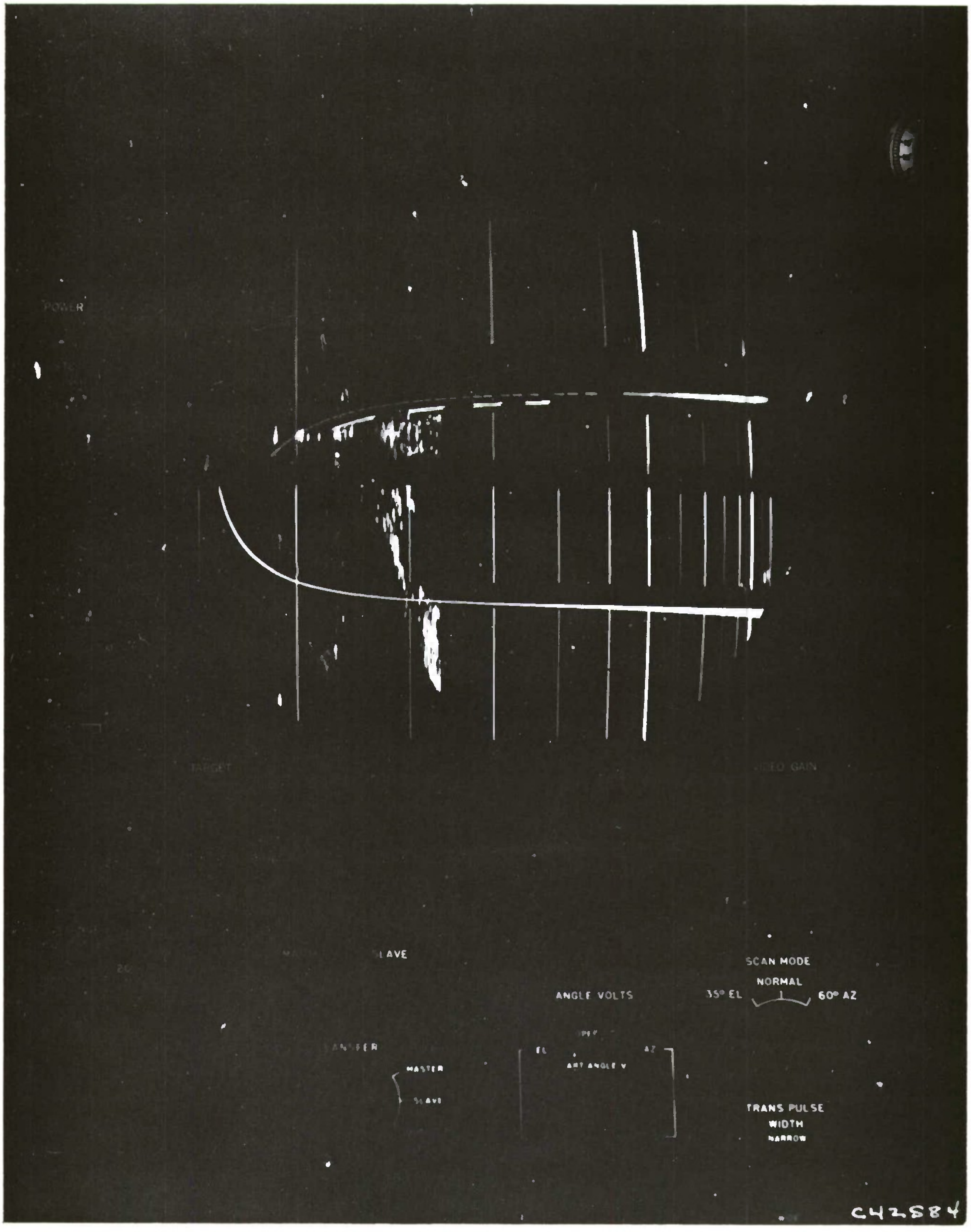

Figure 11. Indicator Photograph Showing 2-Degree Glideslope, CP, STC, IAR
(See Figure 16)

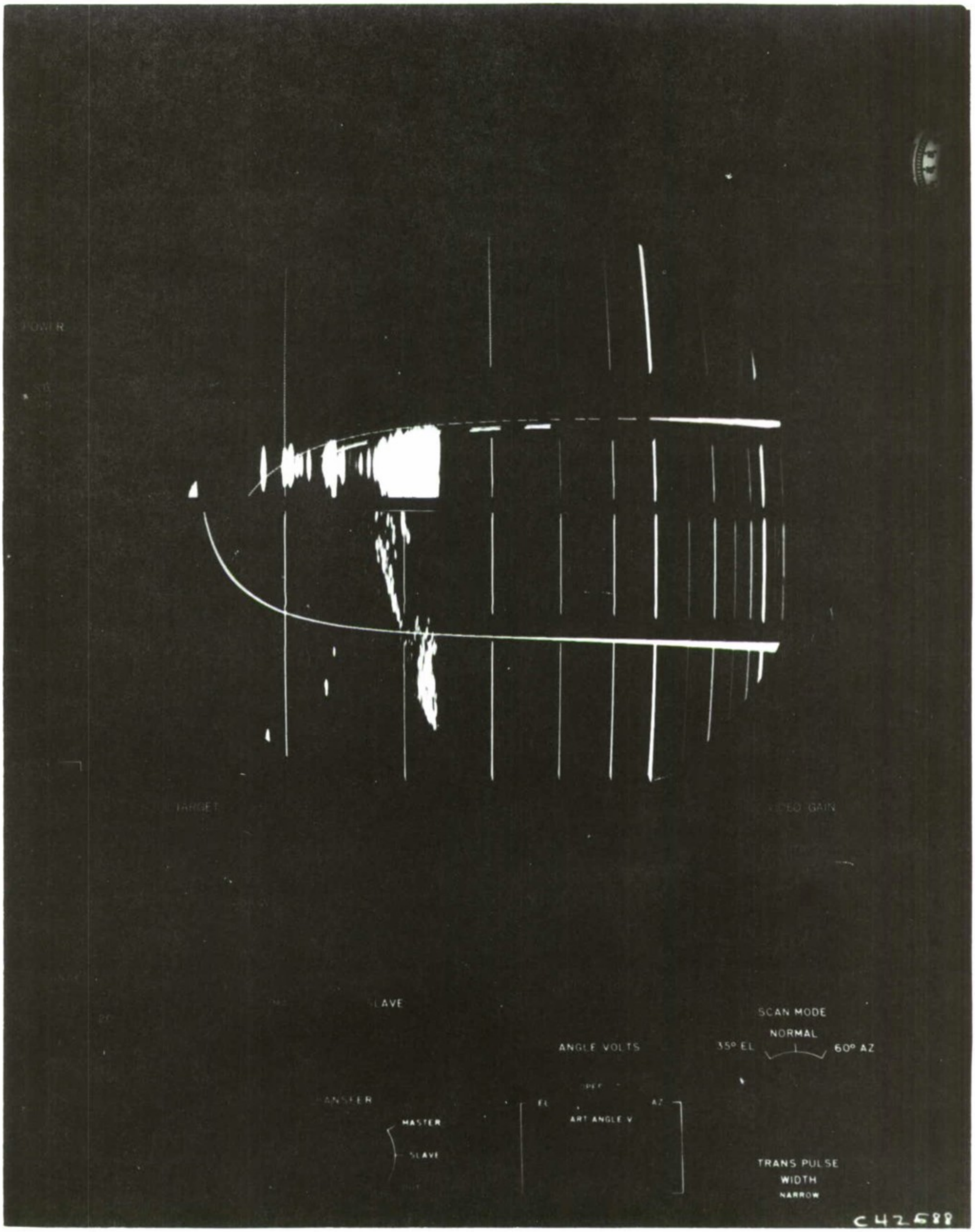

Figure 12. Indicator Photograph Showing 2-Degree Glideslope, LP, STC, No (See Figure 16)

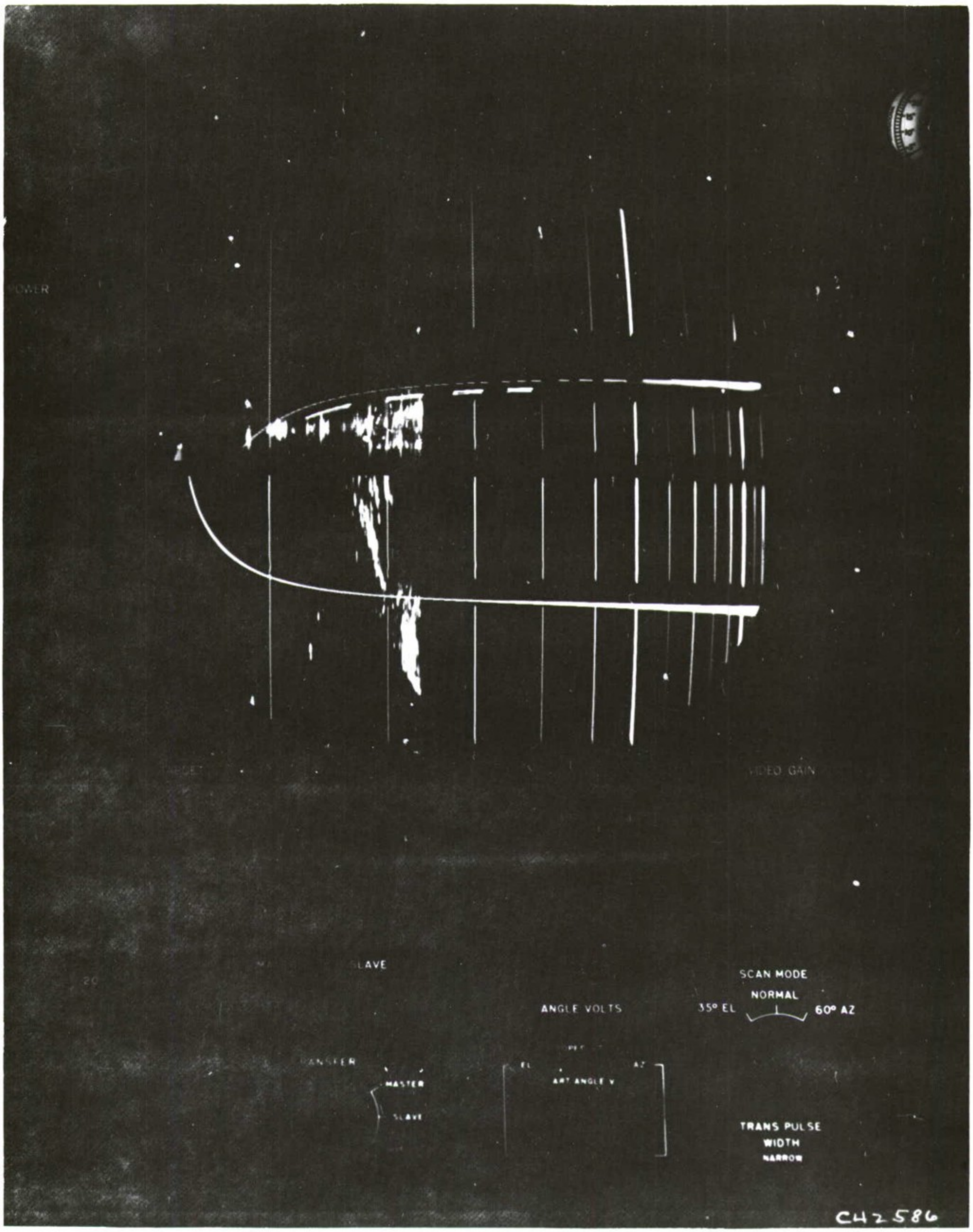

Figure 13. Indicator Photograph Showing 2-Degree Glideslope, LP, STC, IAR
(See Figure 16)

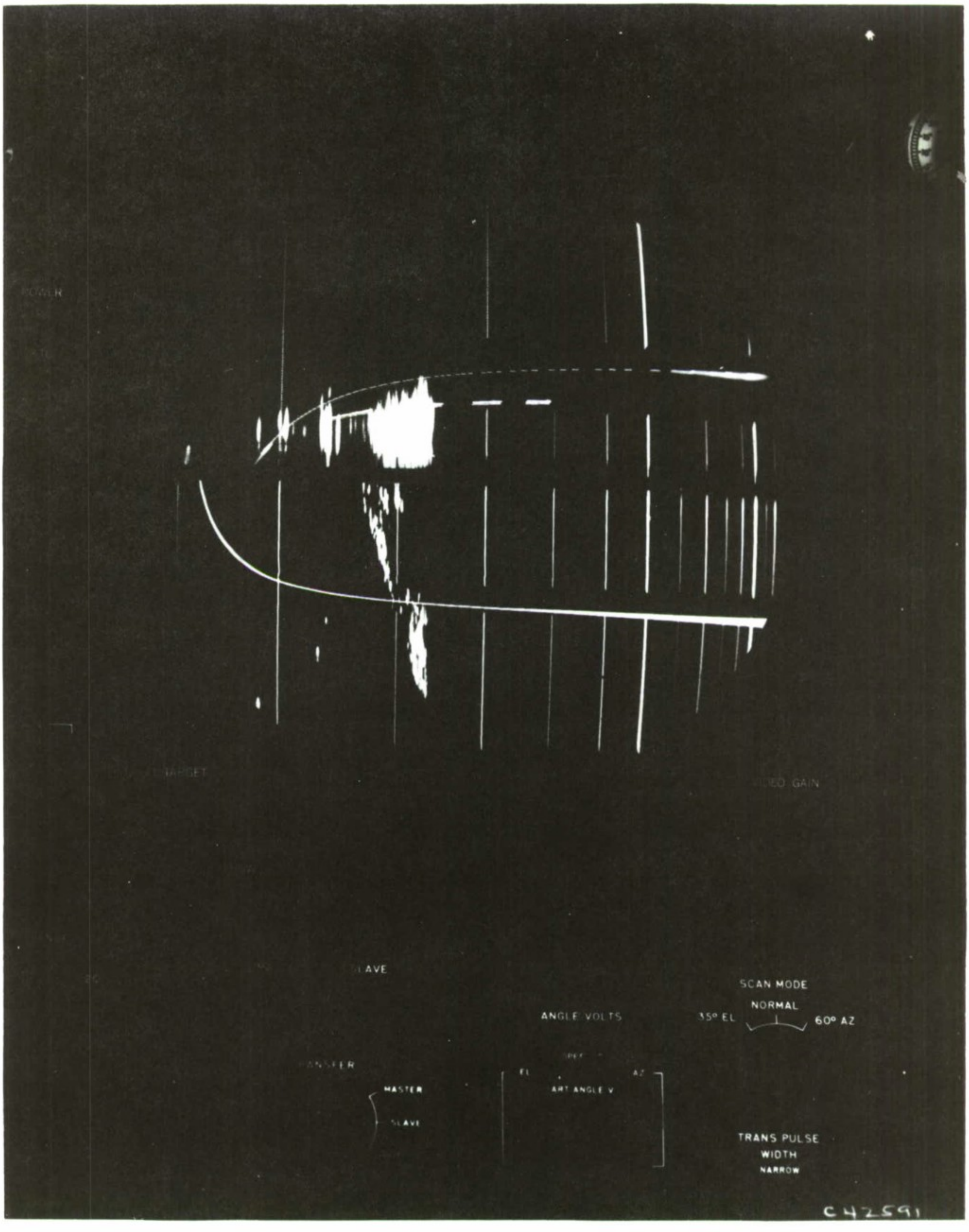

Figure 14. Indicator Photograph Showing 3-Degree Glideslope, CP, STC, No IAR
(See Figure 16)

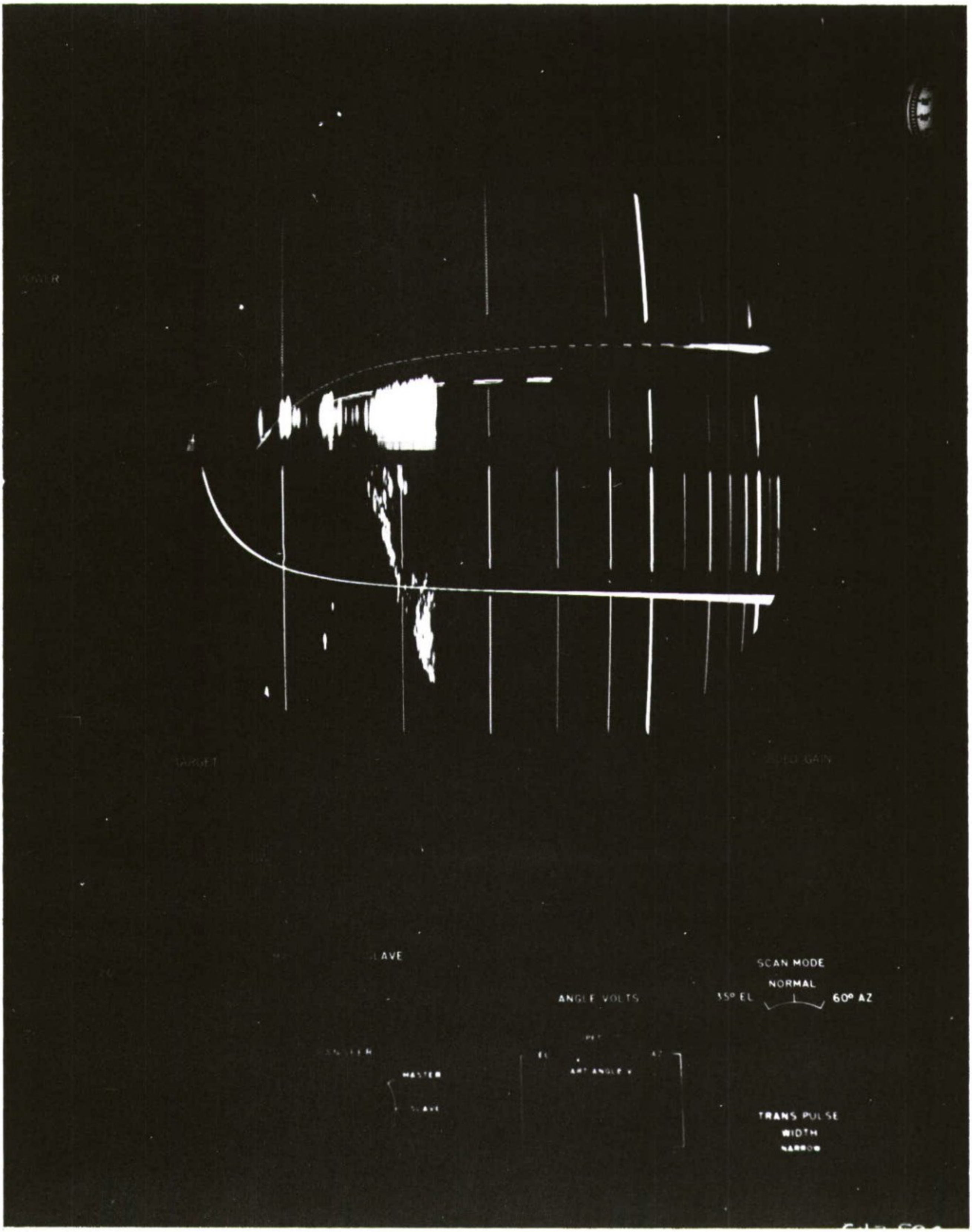

Figure 15. Indicator Photograph Showing 3-Degree Glideslope, LP, STC, No IAR
(See Figure 16)

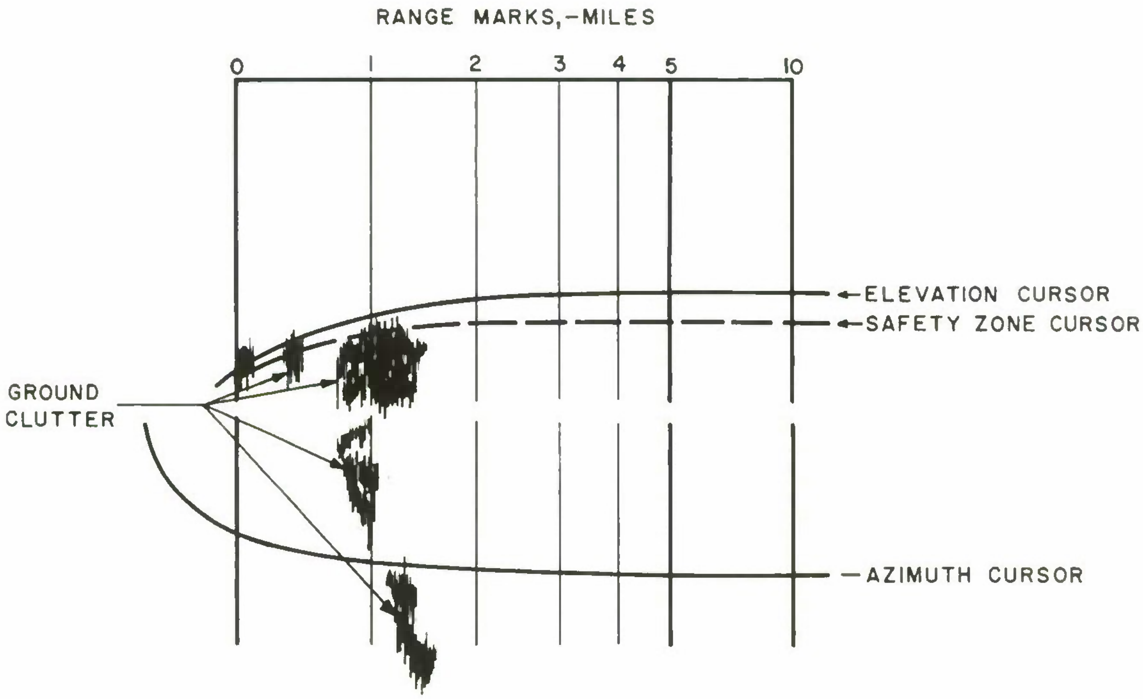

Figure 16. Explanation of Features of Photographs, Figures 10-15

Comparison of figure 10 and 12 indicates a slight increase of clutter in the circular polarization mode as against the normal mode of linear polarization. This is to be expected, as the circular mode is effective primarily against rain, where the rain drop "targets" have nearly spherical surfaces and nearly equal signal components are returned for cancellation. Against terrain and vegetation, CP is much less effective, since their surfaces are extremely non-spherical, and the returning components of the signal will be random in relative amplitudes, and may have a slight tendency to add at times, giving greater ground clutter than linear polarization. A greater probability is that a different pattern exists, perhaps with higher sidelobes, resulting in greater clutter return.

The operation of IAR is as follows. The elevation antenna has a dual feedhorn which provides a monopulse sum and difference output. The maxima of the elevation antenna difference patterns are approximately 1.2 degrees apart, with a 35 db null at beam center. Thus, a target illuminated by any portion of the beam other than the center will produce a difference output other than zero, as well as a sum output. The log amplifier receives monopulse difference signals from the pre-amp and amplifies them in accordance with the instantaneous value of the difference function. The output of the log amp is applied as a bias to the sum channel, and begins to take effect when the sum channel input is approximately 6.5 db above MDS. Since the antenna difference pattern is approximately the inverse of the sum pattern, the output of the difference channel log amplifier provides the greatest attenuation at the skirts of the sum pattern, and minimum at beam center. Thus, a narrowing of the elevation video input to the indicator is achieved, to attain greater tracking accuracy. The amount of IAR is variable by the "El Target" control on the indicator front panel, to a maximum narrowing factor of three.

Figures 11 and 13 show the effect of IAR against clutter; this was not with maximum IAR, but was the optimum adjustment considering the simultaneous reduction of clutter and target size. No flights were being conducted on the day the photographs were taken, so that it was necessary to use a "target of opportunity" for determination of this optimum adjustment. Unfortunately, he did not wait to be photographed. Even with the use of IAR, this amount of clutter might be of some concern, so a 3° glideslope was set up to completely clear the existing clutter. This condition is shown in figures 14 and 15 for circular and linear polarization, respectively; since the glideslope is clear of clutter, no IAR was used here. The safety zone cursor shown is the same as for the 2° glideslope, although this may be changed if desired.

From the foregoing, it may be concluded that with the existing equipment, the first approach to the problem of surrounding terrain clutter is to use a higher glideslope, and then apply IAR, if still necessary. Although the probable major usage will be on the 2° and 3°

glideslopes wherever possible, steeper approaches are easily available for adverse terrain conditions. The system is designed to accommodate glideslopes up to 20°, although it is unlikely that frequent use of slopes greater than 5° will be required. At 5°, the rate of descent is in the order of 1300 feet per minute for an approach speed of 150 mph; this is a bit speedy, but not unreasonable. During the flight tests at Edwards AFB, no difficulty was encountered by either pilot or PAR operator in using this approach angle; even a 10° approach posed no problems for the pilot making these glides, although this is admittedly somewhat steep for normal usage.

The MTI mode of operation is available in some existing GCA systems, but is very seldom, if ever, used by operators during aircraft approaches. The main reason seems to be that the corner reflectors flanking the touchdown point, and used to locate the courseline and glideslope cursors, are not visible in the MTI mode, and the operators are not confident that the cursors will not draft from their optimum positions. MTI will effect some clutter reduction, but requires an appreciable amount of circuit complexity for incorporation into the system. There is also a "blind speed" problem, particularly in a PAR; for the AN/TPN-14, there are four blind speeds within the range of 60-205 knots of glideslope entry and flareout speeds. PRF staggering alleviates the blind speed problem somewhat, but still results in reduced sensitivity. It is questionable whether MTI would actually result in worthwhile improvement in this system.

It is our recommendation that MTI not be considered as a modification in the first three AN/TPN-14 systems. If in the light of subsequent experience and consideration of alternate methods of clutter reduction, it is deemed desirable to include it as a modification in future systems, there are several possible approaches, at least one of which would be absolutely necessary. One would be tests and operator education to show that the cursors do not drift in the MTI mode. Another would be the use of phase-shifting reflectors which would be visible in MTI, and probably the simplest would be gating the MTI on at a range beyond the reflectors, so that they would appear in the normal mode; this last would permit the continued use of existing standard reflectors.

APPENDIX 1

Reference Excerpts From MIL-R-27921 (USAF) Amend. 3

3. 4. 2. 3 The longevity period for the AN/TPN-14 shall be 20,000 hours with the exception that the antenna drive unit longevity period shall be 10,000 hours.

3. 4. 5 Arrangement of components. - All components of the AN/TPN-14 shall be readily accessable from the front of the rack for tune-up and operation. They shall be easily removable for major overhaul.

3. 4. 11. 2 Equipment. - This category includes all items furnished with, or as a part of, each AN/TPN-14 which are not included in 3. 4. 11. 1. 1. This equipment shall meet the following requirements without exceeding the system tolerances specified herein.

a. Operating. - When installed in the shelter with the doors either open or closed, and properly aligned at 32 degrees Centigrade, the radar set shall operate within system tolerances specified herein, with no further alignment, over a range of 0 degrees Centigrade to 52 degrees Centigrade. When adjusted at minus 15 degrees Centigrade, it shall operate within system tolerances specified, with no further alignment, between 0 degrees Centigrade and minus 40 degrees Centigrade. No damage shall result to the set or its component parts when energized at temperatures down to minus 40 degrees Centigrade.

3. 4. 11. 2. 3 Rain and snow. - The equipment shall be capable of operating without degradation in performance and without damage under conditions of rainfall up to two inches per hour, or snowfall up to one inch per hour. Equipment shall be tested in accordance with Specification MIL-E-4970 with shelter doors open and snow or rain falling at a 45 degree angle.

3. 4. 12 Service conditions (mechanical). - The AN/TPN-14 shall be constructed so that no fixed part will become loose, no moveable part or permanently set adjustment will be shifted in setting or position, no part will be damaged and no degradation will be caused in the performance specified herein when subjected to the following conditions.

3. 4. 12. 1 The shelter and equipment inside, in transport configuration, shall accept a 15G longitudinal shock and a 10G lateral shock both of 11 millisecond duration.

3. 4. 12. 3. 1 Cross-country rail transportation including humping at 8 m. p. h.

3. 4. 12. 3. 2 Vibration. - The shelter, with equipment mounted inside in transport condition, shall be mounted on a wheeled chassis and towed over a gravel road for a distance of 250 miles at a speed of 30 m. p. h. This test shall include at least 30 sudden stops from 30 m. p. h.

3.4.13 Service conditions (electrical). - The AN/TPN-14 shall operate from input power of 208/120 volts, three phase, four wire, 400 cycles, with following parameters:

a. Frequency. - Within plus or minus five percent of nominal frequency from no load to full load; within plus or minus two percent nominal frequency at any fixed load.

b. Voltage. - Within plus or minus 2.5 percent of nominal voltage from no load to full load; within plus or minus 1.0 percent of nominal voltage at any fixed load.

3.4.14 Service life. - The AN/TPN-14 set shall have a minimum service life of ten years. It shall be operated 23 hours per day with one hour shutdown, if required, for maintenance.

3.4.22 Test points. - Test points shall be provided for essential wave form and voltage measurements where terminals are not otherwise accessible. These test points shall be identified with a designation, for example: "TP-101". Markings on the chart shall be provided showing the normal wave form pattern at each test point. The pattern chart shall be attached in a location which can be easily seen while testing the unit. In addition, for all sockets where space and design limitations prevent the use of test points, an analyzer adapter socket shall be provided to aid in making voltage and pattern measurements. "All other test points shall be in compliance with MIL-T-4207."

3.5.1.2 Construction. - The elevation antenna shall be constructed from epoxy laminate honeycomb fiberglass with sufficient backing structure to insure no detrimental flexure when subjected to climatic service conditions specified in 3.4.11.1, 3.4.11.2.1 and 3.4.11.2.2.

3.5.1.8 Horizontal servo. - The elevation antenna shall be capable of being slewed horizontally through plus or minus 15 degrees. Antenna servo shall be controllable from the radar indicator unit.

3.5.1.11 Azimuth positioning. - The elevation antenna shall be capable of being positioned in azimuth through plus or minus 15 degrees from normal boresight angle.

3.5.1.12 Mechanical dimensions. - The elevation antenna shall not exceed the following dimensions (with cosecanting plates removed):

a. Height: 8 feet

b. Width: 2.5 feet

c. Weight: 90 pounds

3.5.2.2 Construction. - The azimuth antenna shall be constructed from epoxy laminate honeycomb fiberglass with sufficient backing structure to insure no detrimental flexure when subjected to climatic service conditions specified in 3.4.11.1, 3.4.11.2.1 and 3.4.11.2.2.

3.5.2.10 Antenna position indicator. - The azimuth antenna drive gearbox shall contain a protractor and pointer display to indicate the antenna horizontal scan position. A window shall be provided in the azimuth drive gearbox housing for viewing this display.

3.5.2.11 Mechanical dimensions. - The azimuth antenna shall not exceed the following dimensions:

a. Length: 6.5 feet
b. Width: 4 feet
c. Weight: 85 pounds

3.5.3.9 Unblanking pulse. - The unblanking pulse to the control indicator shall be a DC gate which is activated by a cam operated microswitch circuit.

3.5.4.3 Mechanical dimensions. - The transmitter-receiver group shall not exceed the following dimensions:

a. Height: 30 inches
b. Width: 25 inches
c. Depth: 25 inches
d. Weight: 250 pounds

3.5.5 Radar transmitter. - The radar transmitter shall consist of a high voltage power supply, pulse forming and transmitting circuitry, and necessary control circuitry. It shall have a pulse type emission with a magnetron oscillator which shall provide a peak power output of 200 plus or minus 25 kilowatts at a PRF (pulse repetition frequency) of 1200 cycles per second and a pulse width of 0.2 or 0.8 microseconds selectable.

3.5.5.1 High voltage power supply. - The high voltage power supply shall consist of a three phase Wye connected transformer and three solid-state rectifiers. The input to the transformer shall be 400 cycle, 120 volt AC, three phase voltage.

3.5.5.2 Pulse forming and transmitting circuits. - The pulse forming and transmitting circuits shall consist of a trigger source, a thyratron modulator, a pulse forming network, a damping diode, a pulse transformer and a tunable magnetron oscillator.

3.5.5.4 Power. - The peak power output shall be 200 plus or minus 25 kilowatts.

3.5.5.9 Pulse width. - The pulse width shall be 0.2 pulse or minus 0.05 microseconds or 0.8 plus or minus 0.1 microseconds. Pulse width shall be manually selectable at the radar control indicator.

3.5.6 Radar receiver. - The radar receiver shall be a single conversion super heterodyne receiver which will operate as both a single and a dual channel system. The two channels shall be identified as the sum channel and the difference channel. The sum channel shall consist of a crystal mixer, IF preamplifier, delay circuit and IF amplifier. The difference channel shall consist of a crystal mixer, IF preamplifier, log IF amplifier. During the azimuth portion of the antenna scan the return signals shall be fed to the sum channel of the receiver. The output of the sum channel shall be fed to a video amplifier from which the output video shall be routed to the radar control indicator. During the elevation portion of the antenna scan the return signals shall be fed to both the sum and difference channels. The output from the difference channel shall be used to control the gain of the sum channel. The IF signal of the sum channel shall be delayed before amplification to allow time for the difference channel output to regulate the gain of the sum channel amplifier. This shall provide instantaneous automatic gain control (IAGC) of the radar receiver to produce increased angular resolution (IAR) on the elevation portion of the control indicator.

3.5.6.1 Minimum detectable signal. - The minimum detectable signal shall be minus 100 dbm with the 0.8 microsecond pulse width and minus 92 dbm with the 0.2 microsecond pulse width. A test coupler integral with the transmitter-receiver group shall be provided for this measurement.

3.5.6.2 Noise figure. - The receiver noise figure shall be less than 10.5 db.

3.5.6.3 Bandwidth. - The overall IF bandwidth, minus the video amplifier, shall be 2.0 megacycles for the 0.8 microsecond pulse width and 8.0 megacycles for the 0.2 microsecond pulse width. The selection of the bandwidth shall be an automatic function dependant upon the position of the pulse width wide-narrow switch on the control indicator.

3.5.6.4 L.O. - The local oscillator shall be a reflex klystron. The output of the klystron shall be divided and fed to the sum channel, difference channel, and AFC crystal mixers. Adjustable waveguide attenuators shall be used as required to control the local oscillator power level incident to the crystal mixers. Tuning of the L.O. shall be accomplished as specified in 3.5.4.1 when the AFC is not in use.

3.5.6.5 IF preamplifier. - The sum and difference channels shall have identical IF preamplifiers. The preamplifiers shall have the following characteristics:

a. Gain: 27 db min.
b. Bandwidth: 18 ±2 megacycles
c. Center frequency: 60 ±1 megacycles
d. Noise figure: 3.35 max.

3. 5. 6. 6 IF amplifier. - The IF amplifier (sum channel) shall have the following characteristics:

a. Gain: 80 db minimum for 0. 2 microsecond pulse width use; 84 db minimum for 0. 8 microsecond pulse width use.

b. Bandwidth: 16. 01 ±1 megacycles for 0. 2 microsecond pulse width. 2. 0 plus 0. 5, minus 0. 25 mcs. for 0. 8 microsecond pulse width. Bandwidth automatically selected for appropriate pulse width.

c. Center frequency: 60 ±0. 5 megacycles for 0. 2 microsecond pulse width; 60 ±0. 2 megacycles for 0. 8 microsecond pulse width.

d. Dynamic range: 48 db minimum.

3. 5. 6. 7 Log IF amplifier. - The log IF amplifier (difference channel) shall have the following characteristics:

a. Gain: 80 db min.

b. Bandwidth: 16 ±1 megacycles

c. Center frequency: 60 ±1 megacycles

d. Dynamic range: 63 db min. at max. gain

3. 5. 6. 8 Video amplifier. - The video amplifier shall have the following characteristics:

a. Gain: 14 db

b. Bandwidth: 500 cycles per second to 6 megacycles

c. Dynamic range: The limiting level shall be adjustable from 6 to 15 db above noise.

3. 5. 6. 9 STC. - The sensitivity time control circuit shall deactivate the radar receiver 610-700 microseconds (40-60 miles) after the system trigger, reducing the gain of the IF preamplifiers to minus 35 db. When activated by the system trigger the STC circuit shall produce an exponential waveform which shall reach maximum level in 100 microseconds. A slope adjust control for adjusting the slope of the STC waveform and a STC gain control for adjusting the maximum level of the STC waveform shall be provided. An STC on-off control shall be provided at the radar control indicator.

3. 5. 6. 10 FTC. A fast time constant function shall be provided for the cancellation of low frequency components of a signal by subtraction of delayed video from undelayed video through a compensated amplifier. The selection of the delay line for the appropriate pulse width shall be an automatic function if two pulse widths are used. An FTC on-off switch shall be provided at the radar control indicator.

3.5.6.11 IF delay line. - The IF amplifier (sum channel) shall contain a delay line to compensate for the natural delay of the IAGC circuitry. The delay line shall have the following characteristics:

a. Delay: 0.24 ± 0.024 microseconds
b. Impedance: 50 ±10 ohms
c. Attenuation: 7.5 ± 1.5 db
d. Isolation of first reflection: 30 db min.

3.5.6.12 L.O. Automatic frequency control. An automatic frequency control device shall be included in the receiver for automatic frequency control of the local oscillator. The AFC shall be capable of reducing the L.O. frequency error to within ±0.1 megacycles of the I.F. reference. After initial alignment, the AFC shall acquire automatically. Automatic acquisition shall occur within two seconds after transmitter turn-on. Mechanical tuning of klystron will be permitted when magnetron frequency is changed mechanically.

3.5.6.13 IF gain. - Gain controls for both the azimuth and elevation portions of the receiver shall be provided at the radar control indicator.

3.5.6.14 Isolation. - Isolation between the azimuth and elevation receiving systems shall be a minimum of 60 db.

3.5.7 Indicator group (general). - The control indicator shall provide an Az-E1 beta scan display with selectable sweep. "The indicator tube shall be Type 10VP7, aluminized. The safety of personnel provisions of MIL-E-4158, regarding X-radiation, shall apply." The deflection shall be a step-sawtooth sweep current fed through a fixed-coil off-center deflection system.

3.5.7.3.12 Cursor fill-in. - In order to avoid gaps in the electronic cursors there shall be a cursor fill-in circuit provided. The cursor shall be formed by providing one pulse per sweep at short ranges and a series of pulses per sweep at long ranges. "After fill in, no gap shall remain which is greater than 50 percent (in length) of the length of the cursor segment on either side of the gap."

3.5.7.4.8 IF gain, Az-E1. - Two concentric knobs shall be provided for control of the receiver gain from the indicator. The inner knob shall control one receiver IF gain and the outer knob or ring shall control the remaining receiver IF gain. The knob labeled Az shall control the sum channel and the knob labeled E1 shall control the difference channel.

3. 5. 7. 6. 11 Mechanical dimensions. - The radar control indicator shall not exceed the following dimensions:

a. Height: 26 inches

b. Width: 23 inches

c. Depth: 23 inches

d. Weight: 165 pounds

3. 5. 8 Target reflectors. - Six frangible target reflectors with masts and baseplates shall be furnished with the AN/TPN-14. Circular polarization gratings shall be furnished with each target reflector.

3. 5. 10. 3. 1. 1 Transmitter band. - The RF transmitter shall be supplied for operation in one frequency band of 7750 to 8400 megacycles. The transmitter shall be capable of operating throughout its specified frequency range using one model of waveguide assembly and a Type QKK-753 klystron as specified in Standard MIL-STD-200.

3. 5. 10. 3. 1. 4 Transmitter power output. - The minimum power output of each transmitter shall be 55 milliwatts.

3. 5. 10. 3. 1. 5 Transmitter waveguide assembly. - Suitable provisions shall be made to minimize diplexing losses of signals appearing in the main waveguide. Phase shifters shall be used as the diplexing facilities to direct energy from the transmitter to the antenna. The klystron shall be isolated from reflections occuring in the waveguide and antenna by a ferrite isolator having a minimum of 40 db reverse attenuation.

3. 5. 10. 3. 1. 6 Transmitter automatic frequency. - The transmitter shall incorporate AFC facilities. The control frequency for AFC operation shall not occupy the transmission base-band. The pull-in range of the transmitter AFC shall be . 05 percent (minimum) of the operating frequency.

3. 5. 10. 3. 1. 7 Video modulation amplifier. - The video modulation amplifier shall have the following characteristics:

a. Input impedance: 75 ohms

b. Gain: 40 db (maximum)

c. Frequency response: 60 cycles per second to 5 megacycles plus or minus 0. 25 db, 20 cycles per second to 7. 5 megacycles plus 0. 5 db minus 1. 5 db.

d. Harmonic distortion: 0. 5 percent at 492 kilocycles (maximum)

e. Hum: Minus 60 db below 6. 3 volts (RMS)

f. 50 cycles per second square wave tilt: Not more than 15 percent

3.5.10.3.2 Receiver. - Each RF Receiver shall include the following:

a. Receiver waveguide assembly

b. Klystron

c. Temperature chamber heating elements and temperature controls

d. Metering facilities for tuning and monitoring

e. 7.0 megacycles alarm receiver

f. Intermediate frequency (IF) amplifier

g. Filaments voltage supply for operating the filaments of all tubes within the receiver

3.5.10.3.2.1 Receiver band. - The RF receiver shall be supplied for operation in one frequency band of 7750 to 8400 megacycles. The receiver shall be capable of operating throughout its specified frequency range using one model waveguide assembly and a type QKK-753 klystron as specified in Standard MIL-STD-200.

3.5.10.3.2.2 Receiver noise figure. - The noise figure of the receiver shall not exceed 15 db.

3.5.10.3.2.3 Receiver waveguide assembly. - Suitable provisions shall be made in the receiver waveguide assembly to minimize diplexing losses of signals appearing in the main waveguide. Phase shifters shall be utilized as the diplexing facility to direct energy from the waveguide manifold to the receiver.

3.5.10.3.2.4 Receiver automatic frequency control. - The receiver AFC shall have the following characteristics:

a. Correction factor: 5 to 1 minimum

b. AFC range: Adjustable to plus or minus 10 megacycles

3.5.10.3.2.5 Intermediate frequency amplifier. - The IF amplifier shall have the following characteristics:

a. Center frequency: 75 mc

b. Bandwidth: 24 megacycles plus or minus 2 megacycles at 3 db point

c. Quieting sensitivity: 6 microvolts for 6 db quieting

d. Gain: 130 db to last limiter grid

e. Video response: 50 cycles per second to 5 megacycles plus or minus 0.5 db and 20 cycles per second to 7.5 megacycles plus or minus 1.5 db.

3.5.10.3.2.6 Alarm receiver. - The alarm receiver shall be designed to detect to a 7.0 megacycles carrier signal generated by the alarm transmitter. This sensing signal shall operate a relay that provides both visual and audio indications of a RF failure at the equipment location.

3.5.10.3.2.6.1 Alarm failure sensing. - The RF failure alarm shall be initiated when the RF carrier to noise ratio drops to a level from 15 db to 25 db. This level shall be adjustable within 15 to 25 db.

3. 5. 10. 3. 2. 6. 1. 2 Additional failures. - In addition to the above, the failure alarm shall be capable of sensing the following failures:

a. Modulation amplifier failure
b. Tone receiver failure
c. Tone transmitter failure
d. RF power supply failure
e. Power source failure
f. Klystron failure
g. Mixer crystal failure
h. IF strip failure

3. 5. 10. 3. 3 Multiplexer, video and trigger. - The video and trigger (VT) multiplexer shall combine the normal video and radar trigger signals into a composite video signal for application to the microwave transmitter. The signals shall be combined to form a bipolar signal in the 100 cycles per second to 6. 9 megacycles portion of the video baseband.

3. 5. 10. 3. 3. 1 Input signal characteristics. - The VT multiplexer shall be capable of satisfactory operation with signal inputs having the following characteristics:

a. Normal video

(1) Source impedance: 50 ohms
(2) Pulse polarity: positive
(3) Level: 4 volts (peak) maximum
(4) Pulse rise time: 0. 05 microsecond maximum

b. Radar trigger

(1) Source impedance: 50 ohms
(2) Level: 15 to 25 volts peak
(3) Pulse polarity: Positive
(4) Pulse width: 1 ± 0. 3 microsecond
(5) Rise time: 0. 05 microsecond
(6) Repetition rate: 1200 pulses per second

3. 5. 10. 3. 3. 2 VT multiplexer characteristics. - The VT multiplexer shall have the following characteristics:

a. Normal video section

(1) Input impedance: 50 or 75 ohms
(2) Input level: 4. 5 volts (peak) maximum

(3) Load impedance: 75 ohms

(4) Output level: 0.25 volts (peak)

(5) Output polarity: Positive

(6) Introduced rise time: 0.03 microsecond

(7) Overshoot: 5 percent maximum

b. Radar trigger section

(1) Input impedance: 50 or 75 ohms

(2) Input level: 10 to 50 volts (peak)

(3) Load impedance: 75 ohms

(4) Output level: 0.25 volts (peak)

(5) Output polarity: Negative

(6) Introduced rise time: 0.08 microsecond maximum

(7) Overshoot: 5 percent maximum

3.5.10.3.4 Analog data transmitter. - The azimuth position of the azimuth scan antenna, the elevation (tilt) position of the azimuth scan antenna, the elevation position of the elevation scan antenna, and the azimuth position of the elevation scan antenna shall be in the form of DC voltage outputs obtained from potentiometers geared to the respective antennas. Each via FM subcarriers. Analog data transmitters shall be used to convert each of the DC outputs of the antenna azimuth and elevation potentiometers to a suitable code for modulation of the FM subcarriers.

3.5.10.3.4.1 Input signal characteristics. - All analog data transmitters shall be electrically and physically interchangeable and shall be capable of satisfactory operation, with a minimum of switching and/or adjustment, with any of the following signal inputs.

a. Azimuth position of Azimuth scan antenna

(1) Level

a. 30 degrees scan: minus 1.0 volt to plus 10.4 volt

b. 60 degrees scan: minus 1.0 volt to plus 19.9 volt

(2) Source impedance: Less than one (1) ohm for load impedance of 15,000 ohms.

(3) Scan rate

a. Degrees: 70 degrees per second maximum.

b. Volts: 22 volts per second maximum.

Maximum error: Input voltage error shall not be more than the equivalent of 0.1 degree.

(4) The minimum load impedance presented to the radar shall be 15,000 ohms.

b. Elevation (tilt) position of azimuth scan antenna

(1) Level (26 degree tilt range): 0 to minus 30 volts

(2) Source Impedance: 0 to 625 ohms

(3) Slewing rate

a. Degrees: 6.0 degrees per second maximum

b. Volts: 6.0 volts per second maximum

(4) Maximum error: Input voltage error shall not be more than the equivalent of 0.5 degree.

(5) The minimum load impedance presented to the radar shall be 40,000 ohms.

c. Elevation position of elevation scan antenna

(1) Level

a. 11 degree scan: minus 1.3 to plus 5.5 volts

b. 35 degree scan: minus 1.3 to plus 16 volts

(2) Source impedance: less than one (1) ohm for load impedances of 15,000 ohms.

(3) Scan rate

a. Degrees: 130 degrees per second maximum

b. Volts: 55 volts per second maximum

(4) Maximum error: Input voltage error shall not be more than the equivalent of 0.1 degree.

(5) The minimum load impedance presented to the radar shall be 15,000 ohms.

d. Azimuth position of elevation scan antenna.

(1) Level (30 degree servo range): 0 to minus 30 volts

(2) Source impedance: 0 to 625 ohms

(3) Slewing rate

a. Degrees: 5.0 degrees per second maximum.

b. Volts: 4.0 volts per second maximum.

(4) Maximum error: Input voltage error shall not be more than the equivalent of 0.5 degree.

(5) The minimum load impedance presented to the radar shall be 40,000 ohms.

3.5.10.3.4.2 Analog data transmitter characteristics. - The analog data transmitter shall have the following characteristics:

a. Input impedance: The input impedance shall be equal to, or in excess of the values specified in 3.5.10.3.4.1.

b. Input level: Shall accept input levels ranging from minus 1.3 volts to plus 19.9 volts (maximum) and from zero volts to minus 30 volts (minimum).

c. Input polarity: Positive or negative (desired polarity selected by switch).

d. Load impedance: Not less than 1000 ohms.

e. Output level: 1.5 volt (peak to peak) nominal. Shall be adjustable for proper modulation of subcarrier transmitter.

f. Accuracy: The accuracy shall be such that when the analog data is decoded and reproduced at the AN/TSW-5, the error referred to the input at the PAR terminal, shall not be greater than the values specified in 3.5.10.4.7.

3.5.10.3.5 Gate signal converter. - The gate signal converter shall convert the unblanking gate signal and the relay gate signal into a form suitable for transmission over the microwave group via two FM subcarrier transmitters. The converter shall convert the positive going edge of the gate signal to a positive pulse and the negative going edge of the gate signal to a negative pulse. Characteristics of the gate signal converter and the input and output signals shall be as follows:

Gate Condition (Assuming change from opposite condition)	Gate Output (Input to Converter)	Input Rise or Decay Time	Source Impedance	Converter Pulse Output Level (Input to S. C. Transmitter)
a. Unblanking gate section				
UNBLANKED	0 volts	1 millisecond maximum	0 ohms	plus 1.0 volt (peak) maximum
BLANKED	open circuit	1 millisecond maximum	Diode gate	minus 1.0 volt (peak) maximum

Gate Condition (Assuming change from opposite condition)	Gate Output (Input to Converter)	Input Rise or Decay Time	Source Imped- ance	Converter Pulse Output Level Input to S. C. Transmitter
b. Relay gate section				
ON	plus 28 volts	1 millisecond maximum	less than 10 ohms	plus 1. 0 volt (peak) maximum
OFF	0 volts	1 millisecond maximum	100 ohms	minus 1. 0 volt (peak) maximum

The output impedance of the gate signal converter shall be such that no loading of the output signal shall be caused by the input impedance of the subcarrier transmitter. The output levels shall be adjustable for proper modulation of the subcarrier transmitters.

3. 5. 10. 3. 6 Order wire communications assembly. - The order wire communications assembly shall consist of a combination FM receiver-transmitter which shall provide simplex voice communication over the microwave link. In addition to the FM subcarrier receiver-transmitter, the assembly shall include audio termination facilities, a handset or microphone, a speaker, and a power supply for plate and filament voltages. The assembly shall have the following characteristics:

a. Frequency: A fixed frequency shall be provided which shall be compatible with that of the order wire assembly at the AN/TSW-5 terminal. The frequency shall be selected to enable the most efficient utilization of the basebands throughout the system.

b. Receiver bandwidth (3 db): plus or minus 300 kc

c. Receiver sensitivity: 1. 0 millivolts maximum, for a signal plus noise to noise ratio of 10 db. The audio output shall be quieted by a positive acting squelch circuit at all times except when a carrier is being received. The point at which the receiver squelch operates shall be adjustable.

d. Transmitter deviation: plus or minus 16 kilocycles for 0. 355 volts rms.

e. Transmitter output: 0 to 50 millivolts

f. Load impedance: 75 ohms

g. Audio bandwidth: From not more than 300 cycles per second on lower end to not less than 3000 cycles per second on upper end within plus 1 and minus 3 db with reference to 1000 cycles.

3. 5. 10. 3. 6. 1 Voice communications over cable. - The order wire communications assembly shall be designed in a manner that shall enable the voice frequency circuits in the assembly to be utilized to transmit and receive simplex voice communications over two wires in an external cable not less than 1000 feet long. A switch shall be provided to select the mode of operation: Microwave or cable. The quality of the voice communications over cable shall be equal to that obtained over microwave.

3. 5. 10. 3. 6. 2 Independent operation of order wire communications. - The order wire communications assembly shall be capable of operating independently of the other equipment comprising the microwave terminal. Separate primary power shall be available for the order wire communications assembly when the primary power to the remainder of the microwave terminal is not turned on.

3. 5. 10. 3. 7 Subcarrier transmitters. - Seven subcarrier transmitters shall be utilized to transmit the following information:

a. Encoded analog data corresponding to azimuth scan antenna azimuth
b. Encoded analog data corresponding to azimuth scan antenna elevation
c. Encoded analog data corresponding to elevation scan antenna elevation
d. Encoded analog data corresponding to elevation scan antenna azimuth
e. Converted unblanking gate signal
f. Converted relay gate signal
g. Control tone (voice frequency carrier) signal

The seven transmitters shall be identical except for the frequency of operation. Each transmitter shall be frequency modulated by one of the above signals. The modulated signals shall be combined for application to the microwave transmitter. Three frames shall be provided for mounting the transmitters. Each frame shall make provision for mounting not less than three transmitters, and a switch and meter shall be provided on the front panel of the frame for monitoring the operation of each transmitter. The characteristics of the subcarrier transmitters shall be as follows:

a. Operating frequencies: As required for efficient utilization of the microwave baseband. The frequencies shall be compatible with companion subcarrier receivers at the control center terminal.

b. Audio input level: 0. 5 volts rms

c. Input impedance: 10, 000 ohms

d. Deviation: Plus or minus 15 kilocycles (plus or minus 1. 5 kilocycles) with audio input of 0. 5 volts rms

e. RF output: Adjustable, 0 to 50 millivolts minimum

f. Load impedance: 75 ohms

> NOTE: The operating frequency of the subcarrier transmitter shall be capable of being changed, in the field, to any frequency occupied by another subcarrier transmitter. The change in frequency shall be accomplished with a minimum of test and adjustment.

3. 5. 10. 3. 8 Subcarrier receiver. - Control tone functions shall be received via one FM subcarrier channel. The composite video signal containing the FM subcarrier shall be applied to the subcarrier receiver from the microwave receiver. The subcarrier signal shall be amplified, demodulated, and coupled from the subcarrier receiver to the tone control receivers. A frame shall be provided for mounting the subcarrier receiver, and metering facilities shall be provided on the front panel of the mounting assembly for monitoring the operation of the receiver. The characteristics of the subcarrier receiver shall be as follows:

a. Operating frequency: The frequency shall be the same as that of the companion subcarrier transmitter at the control center terminal.

b. Input level: 2 millivolts rms maximum for 10 to 1 signal plus noise to noise ratio

c. RF bandwidth: Plus or minus 150 kilocycles at minus 3 db points

d. Output impedance: 150/600 ohms nominal

e. Output level: 0 dbm minimum

> NOTE: The operating frequency of the subcarrier receiver shall be capable of being changed, in the field, to any frequency occupied by another subcarrier receiver. The change in frequency shall be accomplished with a minimum of test and adjustment

3. 5. 10. 3. 9 Tone control receiver. - Ten separate control functions shall be received via modulated audio tones. The functions to be controlled are as follows:

a. Azimuth IF gain control

b. Elevation IF gain control

c. Elevation (tilt) control of azimuth scan antenna

d. Azimuth control of elevation scan antenna

e. High voltage ON/OFF control

f. Elevation scan mode control

g. Azimuth scan mode control

h. FTC control

i. STC control

j. Antenna scan ON/OFF control

A tone control receiver shall be provided for each control function, and an additional receiver shall be provided as part of a squelch system to prevent false operation of the control functions during a fade. The combined control tones from the subcarrier receiver shall be applied to the control tone receivers, where each receiver shall filter, amplify, and demodulate its respective tone signal and provide the required output. Each tone control receiver shall have the following characteristics:

a. Operating frequency: Within the range of 500 to 3100 cycles per second

b. Channel spacing: Not less than 170 cycles per second

c. Sensitivity: 16 millivolts

d. Selectivity: Input filter shall provide at least 40 db adjacent channel rejection

e. Output: Contact closures providing a two or three state (as required) control function.

f. Noise protection: Output signals shall be opened when signal plus noise to noise falls below a preset ratio.

The operating frequency of the tone control receiver shall be capable of being changed, in the field, to any frequency occupied by another tone control receiver. The change in frequency shall be accomplished with a minimum of test and adjustment.

3.5.10.3.10 Tone control transmitter. - One tone control transmitter shall be used to transmit the high voltage ON-OFF indication. Frequency shift keying shall be employed and the output shall be used to modulate a FM subcarrier transmitter. The tone control transmitter shall have the following characteristics:

a. Operating frequency: Within the range of 500 to 3100 cycles per second

b. Output level: 1 volt across 600 ohms

c. Channel spacing: Not less than 170 cycles per second

d. Deviation: Plus or minus 42.5 cycles per second. Provisions shall be made for transmitting a two or three state (as required) control function.

e. Keying speed: 37.1 dot-cycle

f. Harmonic output: 40 db below fundamental

The operating frequency of the tone control transmitter shall be capable of being changed, in the field, to any frequency occupied by another tone control transmitter. The change in frequency shall be accomplished with a minimum of test and adjustment.

3.5.10.3.13 Power supply, RF equipment. - The RF equipment power supply shall supply the regulated DC voltages for operation of the klystrons, modulation amplifiers, IF amplifiers, and alarm units in the microwave transmitters or receivers. The power supply shall be capable of supplying not less than 3 microwave receivers, or transmitters, or combination thereof, and shall be designed to operate satisfactorily under normal equipment load or with a 25 percent overload. Additional characteristics shall be as follows:

a. Regulation against temperature - With line voltage and frequency within the operating range and load resistances drawing up to 125% rated load current, no output voltage shall change more than ± 0.5% over the specified temperature range.

b. Regulation against line voltage - With temperature and frequency within the operating range and load resistances drawing up to 125% rated load current, no output voltage shall change more than ±0.5% as the line voltage changes from 117 to 123 volts rms.

c. Regulation against line frequency - With line voltage and ambient temperature within the operating range and load resistances drawing up to 125% rated load current, no output voltage shall change more than ± 0.5% as the line frequency changes from 380 to 420 cps.

d. Regulation against load - With the line voltage, frequency and ambient temperature within the operating range, no output voltage shall change more than ± 1% for simultaneous load current changes from 30 to 125% rated load.

e. Ripple voltage - Maximum ripple voltage shall not exceed 2 millivolts on regulated outputs.

f. Rectifiers - All rectifiers shall be solid state diodes.

g. Circuit protection - Each circuit protected by a fuse or circuit breaker shall have a front panel indicator lamp which illuminates when a protective fuse or circuit breaker is open.

3.5.10.3.15 Parabolic antenna and associated mount, radome and waveguide. - A common parabolic antenna shall be utilized for both the transmission and reception of microwave signals. The antenna shall be attached to the roof of the radar shelter by means of an antenna mounting assembly. A radome shall be provided for protection of the antenna and feedhorn from environmental extremes. The antenna shall be coupled to the microwave receiver and transmitters by a waveguide which shall provide a minimum of attenuation of the microwave signal.

3.5.10.3.15.1 Parabolic antenna. - The parabolic antenna shall have a diameter of 2 feet and shall operate over a 7125 to 8400 megacycles frequency band. When mounted on the radar shelter, provision shall be made for adequate clearance of all physical and electrical obstructions of the radar antennas. The electrical characteristics of the antenna shall be as follows:

a. Gain: 30 db (referred to an isotropic antenna)

b. VSWR: 1.15 maximum (7125 to 8400 megacycles)

c. Efficiency: 55 percent minimum

d. Beamwidth (E and H plane): No greater than 5.0 degrees measured at the half power points

e. Side lobe response: The response at any side lobe shall be at least 18 db below the main lobe.

3.5.10.3.15.3 Antenna radome. - A heated radome shall be supplied for the parabolic antenna. The radome shall be capable of easy installation and removal and shall have the following characteristics:

a. Diameter: 2 feet
b. Attenuation: Less than 1 db in the 7125 to 8400 megacycle range
c. VSWR contribution: Less than 0.03 in the 7125 to 8400 megacycle range
d. Heater: 150 watts, 400 cycles per second, 120 volts

Heating wires shall be oriented to provide radio frequency transparency, yet keep the radome free of ice within the specified range of wind and temperature. Thermostats shall be provided in the radome to turn the heaters on when icing conditions are prevalent. With the radome installed, the antenna and radome shall meet the same rigidity requirements as were previously specified (see 3.5.10.3.15.2.1).

3. 5. 10. 3. 15. 4. 2 Waveguides (rigid). - Rigid waveguides shall be either straight, twisted (left or right) or bent (H or E plane) as specified and shall be capable of withstanding a pressure of 15 pounds per square inch (PSI) without altering its electrical or mechanical characteristics. Additional characteristics shall be as follows:

a. Straight section

    (1) Maximum attenuation: 0. 04 db per foot

    (2) Maximum voltage standing wave ratio (VSWR): 1. 05

b. Bend and twist section

    (1) Maximum attenuation: 0. 04 db per foot

    (2) Maximum VSWR: 1. 05

    (3) Minimum E - plane radius (bend section): 1 3/8 inches

    (4) Minimum H - plane radius (bend section): 1 3/4 inches

    (5) Maximum twist (twist section): 90 degrees per foot

3. 5. 10. 3. 15. 4. 3 Waveguide (flexible). - Flexible waveguides shall be capable of withstanding a pressure of 15 PSI without altering the electrical characteristics and without ballooning or deforming. Additional characteristics shall be as follows:

a. Maximum attenuation: 0. 1 db per foot

b. Maximum VSWR: 1. 10

c. Minimum E - plane radius (bend): 6 inches

d. Minimum H - plane radius (bend): 13 inches

e. Maximum twist: 70 degrees per foot

3. 5. 10. 4. 2. 1 Propagation reliability. - The performance shall be such that the equipment furnished for the PAR microwave group shall be capable of transmitting or receiving a satisfactory signal over a 5 mile path with the transmitter output or receiver input attenuated 25 db. The signal shall not be considered satisfactory if the signal plus noise to noise ratio of any video, subcarrier, or voice frequency carrier channel falls below 10 db.

Provisions shall be made for determining the fade margin over a particular path by means of a precision variable attenuator permanently inserted in the common waveguide between the RF equipment and the antenna, and mounted in the rack directly above the microwave receiver and transmitters. The attenuator adjustments shall be capable of being made from the front of the rack and the scale shall be easily visible from the front of the rack. The attenuator shall be a direct reading FXR W164A or equivalent. In the 7125 to 8400 megacycle frequency range, the attenuator shall have a calibrated attenuation range of zero to 50 decibels with a maximum error of 0.5 decibel or two perdent of reading, whichever is greater, and the insertion loss shall be less than 1 decibel. The VSWR caused by the attenuator shall be less than 1.15, and the performance shall be the same for propagation of microwave energy in either direction through the attenuator.

3.5.10.4.5 Radar video. - The system performance characteristics of the radar video signal shall be as follows:

a. Gain: 0 plus or minus 1.5 db for input levels from 0.2 to 4 volts peak.
b. Frequency response: Plus or minus 1 db from 100 cycles per second to 6 megacycles.
c. Overshoot: Less than 10 percent for a pulse having a rise time of 0.1 microseconds.
d. Droop: Not more than 5 percent for a 300 microsecond pulse.
e. Time jitter: Not more than 0.02 microsecond
f. Amplitude jitter: Less than 1 db
g. Output pulse rise time: Not more than 0.1 microsecond for input rise time of 0.05 microsecond.

3.5.10.4.6 Radar trigger. - The system performance characteristics of the radar trigger shall be as follows:

a. Output level stability: Plus or minus 1 db for variation of from 10 to 30 volts peak input level.
b. Output pulse width: 0.2 microsecond
c. Output pulse rise time: Not more than 0.1 microsecond
d. Overshoot: Less than 5 percent
e. Time jitter: Less than 0.02 microsecond
f. Amplitude jitter: Less than plus or minus 1 db.

3.5.10.4.9.1 Tone control reception. - The following control functions shall be received via the PAR microwave group which shall produce, into the designated load, the outputs listed below for the specified control state selected at the AN/TSW-5.

a. Azimuth IF gain control (3 position function)

Control State	Output Level	Radar Load Impedance
ON	0 volts (ground)	500 ohms
OFF	open circuit	
ON	0 volts (ground)	500 ohms

b. Elevation IF gain control (3 position function)

ON	0 volts (ground)	500 ohms
OFF	open circuit	
ON	0 volts (ground)	500 ohms

c. Elevation (tilt) control of azimuth scan antenna (3 position function):

ON	minus 28 volts	500 ohms
OFF	0 volts	
ON	minus 28 volts	500 ohms

d. Azimuth (servo) control of elevation scan antenna (3 position function):

Control State	Output Level	Radar Load Impedance
ON	minus 28 volts	500 ohms
OFF	0 volts	
ON	minus 28 volts	500 ohms

e. High voltage ON-OFF control (3 position function):

	Circuit #1 (H. V. ON)	Circuit #1
ON	0 volts (ground)	500 ohms
NEUTRAL	open circuit	
OFF	open circuit	
	Circuit #2 (H. V. OFF)	Circuit #2
ON	0 volts (ground)	500 ohms
NEUTRAL	ground	
OFF	open circuit	

NOTE: For high voltage control, a three position switch is used with non-locking (momentary) ON position, locking NEUTRAL (center) position, and locking OFF position.

f. Elevation scan mode control (2 position function):

11 degree scan	minus 28 volts	500 ohms
35 degree scan	minus 28 volts	500 ohms

g. Azimuth scan mode control (2 position function):

30 degree scan	minus 28 volts	500 ohms
60 degree scan	minus 28 volts	500 ohms

NOTE: A separate control line is used for each scan angle and selection of the desired angle is obtained by applying minus 28 volts to the appropriate control line.

h. FTC control (2 position function):

ON	minus 28 volts	1000 ohms
OFF	open circuit	

i. STC control (2 position function):

ON	0 volts	270, 000 ohms
OFF	minus 35 volts	270, 000 ohms

j. Antenna scan ON-OFF control (2 position function):

Control State	Output Level	Radar Load Impedance
ON	minus 28 volts	not less than 200 ohms
OFF	open circuit	

3. 5. 10. 4. 9. 2 Tone control transmission. - The following control function shall be transmitted via the PAR microwave group and shall produce the designated indication at the AN/TSW-5 for the specified output at the PAR site.

a. High voltage indication (2 state function):

Indication	Control Output (Input to Microwave)	Radar Source Impedance
ON	plus 28 volts	low (28 volt source)
OFF	open circuit	infinite ohms

3. 5. 12. 4 Power connector specifications

3. 5. 12. 4. 1 400 cycles per second AC power input connector. - The 400 cycles per second AC power input connector shall be a Crouse-Hinds "ARK-trol" circuit breaking square flanged receptacle with insert, insert clamping nut, dust cap, and square gasket.

The connector shell size shall be 041 (long). The insert shall be a four-pole, non-grounding, male insert, Type P01, with solder type pins capable of accepting 1/0 awg wire. The polarity key shall be in the standard (N) position. This connector is similar to part number 641-014-S0IN except that a POIN insert is required in place of the SO1N insert.

3. 5. 12. 4. 2 Emergency DC input connector. - The emergency DC input connector shall be a Crouse-Hinds "ARK-trol" circuit breaking square flanged receptacle with insert, insert clamping nut, dust cap, and square gasket. The connector shell size shall be 021. The insert shall be a three pole, non-grounding, male insert, Type P02, with solder type pins capable of accepting #10 awg wire. The polarity key shall be in the standard (N) position. This connector is similar to part number RPC-221-014-S02NR except that a P02N insert is required in place of the S02NR insert.

3. 5. 12. 4. 3 400 cycles per second air conditioner power connector. - The 400 cycles per second air conditioner power connector shall be a Crouse-Hinds "ARK-trol" circuit breaking square flanged receptacle with insert, insert clamping nut, dust cap, and square gasket. The connector shell size shall be 033. The insert shall be a four wire-five pole, one pole grounded, female insert, type S02, with solder type contacts, capable of accepting #10 awg wire. The polarity key shall be in the standard (A) position. This connector is similar to part number RFC-233-014-S02AR except that solder type contacts are required in place of the solderless contacts.

3. 5. 12. 4. 4 400 cycles per second AC power output connector. - The 400 cycles per second AC power output connector shall be a Crouse-Hinds "ARK-trol" circuit breaking square receptacle with insert, insert clamping nut, dust cap, and square gasket. The connector shell size shall be 041 (long). The insert shall be a four-pole, non-grounding, female insert, type S01, with solder type pins capable of accepting 1/0 awg wire. The polarity key shall be in the standard (N) position. This connector is identical to part number RPC-641-014-S01N.

3. 5. 12. 4. 5 400 cycles per second convenience receptacle. - The 400 cycles per second convenience receptacles shall be military type UR104F power, three-wire, polarized, twist-locking type, electrical receptacle connectors. The receptacles shall be mounted in weather-tight screw-on dust caps.

3. 5. 13 Communications and intercommunications. - The AN/TPN-14 shall contain UHF and VHF air-ground-air (AGA) communications capability. There shall be provisions for intercommunication with all other shelters of the AN/TSQ-47 air traffic control/communications system. The AGA communication system shall consist of one multi-channel UHF transceiver with associated antenna and control equipment, one VHF transmitter and VHF receiver with

associated antenna and control equipment and one 28 volt DC power source. The intercommunications system shall consist of a wireless intercommunication system utilizing the RACEP technique for encoding, transmitting, receiving and decoding voice messages.

3.5.13.1 UHF communications. - The UHF transceiver shall be a Collins 618A-13 or its equivalent. The transceiver shall have the following characteristics.

3.5.13.1.3 Power output. - The RF power output from the UHF transmitter shall be 20 watts average into a 52 ohm resistive load.

3.5.13.1.7 Antenna. - The UHF antenna shall be a broad band discone type such as the AT-197 or its equivalent.

3.5.13.1.8 Mechanical dimensions. - The UHF transceiver shall not exceed the following dimensions:

a. Height: 8 inches
b. Width: 11 inches
c. Depth: 20 inches
d. Weight: 52 pounds

3.5.13.1.9 Selectivity. - The overall selectivity of the UHF receiver shall fall within the limits set forth below for standard service conditions.

Attenuation below resonant response	Total guard receiver	Bandwidth main receiver
6 db	60 kilocycles minimum	60 kilocycles minimum
60 db	400 kilocycles maximum	200 kilocycles maximum

Image and other spurious responses shall be attenuated at least 60 db relative to the desired signal for any channel on the main receiver.

3.5.13.1.10 Sensitivity. - The sensitivity of the receiver shall be such that when an RF input of five microvolts (open-circuit) modulated 30 percent at 1000 cycles per second is applied, the audio output power shall be at least 50 milliwatts with a signal plus noise to noise ratio (modulated to unmodulated) of 10 db or greater.

3.5.13.1.11 Receiver AVC characteristics. - The AVC action shall be such that when a 1000 microvolt signal modulated 30 percent at 1000 cycles is applied, the audio output power shall be 250 milliwatts (plus or minus 15 percent). When the signal input (30 percent modulated at 1000 cycles) is varied from 10 microvolts to 100,000 microvolts, the audio output power shall not vary by more than plus or minus 3 db from the audio output obtained with the 1000-microvolt signal. When a main frequency within five megacycles of the guard frequency is selected the foregoing requirements need be met only over the range from 20 to 100, 000 microvolts.

3. 5. 13. 1. 12 Receiver noise peak limits. - The receiver shall employ necessary circuits to provide instantaneous noise peak limiting. The noise limiting action shall effectively limit the audio output voltage of modulating surges or peaks exceeding 50 percent plus or minus 15 percent modulation of the RF signal. Its action shall be rapid enough to prevent continuous RF noise such as are caused by commutators, ignition systems, etc.

3. 5. 13. 1. 13 Receiver squelch. - The main receiver shall provide a squelch circuit controlled by the audio signal plus noise-to-noise ratio. Under conditions of five microvolts RF input modulated at 400 cycles per second the squelch control provided within the receiver-transmitter shall have a range as to permit squelch operation from no modulation to greater than 30 percent modulation. With the squelch control adjusted to obtain normal audio output with modulation input required for 6 db signal plus noise-to-noise ratio, the audio signal shall be effectively suppressed when the modulation input is reduced to a 1 db signal plus noise-to-noise ratio.

3. 5. 13. 1. 14 UHF receiver input impedance. - The receiver input impedance shall be 52 ohms unbalanced.

3. 5. 13. 2 VHF communications. - The VHF communications equipment shall consist of a Collins VHF-101 airborne communications set or its equivalent, plus necessary control equipment and power supply. The basic VHF-101 set contains one Collins 17L-7 VHF transmitter, one Collins 51X-2B VHF receiver, one Collins 614U-6 remote control unit, and one Collins 390E-2 dual shock mount. These components shall have the following characteristics.

3. 5. 13. 2. 1 Receiver frequency range. - The receiver shall have a channelized frequency range of 108 to 151. 95 megacycles. It shall provide 880 channels selectable in 50 kilocycle increments by remote control.

3. 5. 13. 2. 1. 1 Receiver input power. - The input power to the VHF receiver shall be single phase, 400 cycle AC and 27. 5 VDC.

3. 5. 13. 2. 2 Receiver sensitivity. - The receiver shall provide at least 6 db signal plus noise-to-noise ratio for a 3 microvolt input signal on all channel frequencies.

3. 5. 13. 2. 2. 1 Selectivity. - The signal rejection characteristics of the receiver shall fall within the limitations set forth below.

Attenuation below resonant response	Total band Total bandwidth
6 db	40 kilocycles minimum
60 db	77 kilocycles maximum

All spurious response including images shall be at least 80 db down.

3. 5. 13. 2. 3 Receiver AVC characteristic. - The receiver shall have necessary AVC circuits such that the audio output shall vary not more than 4 db over a RF input range from 5 microvolts to 100, 000 microvolts.

3. 5. 13. 2. 4 Receiver noise limiter. - A noise limiter circuit shall be provided in the receiver to reduce adverse effects due to ignition noise and other impulse-type interference.

3. 5. 13. 2. 5 VHF receiver squelch. - A carrier operated squelch circuit shall be provided to mute the receiver until application of any preset input from receiver threshold noise level to 25 microvolts. Squelch threshold shall be constant within 10 percent with modulation variation from 0 to 90 percent.

3. 5. 13. 2. 6 VHF receiver input. - The receiver input shall be 52 ohms unbalanced.

3. 5. 13. 2.7 Mechanical dimensions. - The VHF receiver shall be contained in a three-eights ATR short chassis. The weight shall not exceed 11 pounds.

3. 5. 13. 2. 8 Transmitter frequency range. - The transmitter shall have a channelized frequency range from 116 to 149. 95 megacycles. It shall provide 680 channels selectable in 50 kilocycle increments by remote control.

3. 5. 13. 2. 9 Transmitter input power. - The input power shall be single phase, 400 cycle AC and 27. 5 VDC.

3. 5. 13. 2. 10 Transmitter power output. - The RF power output shall be 25 watts into a 52 ohm resistive load.

3. 5. 13. 2. 11 Transmitter duty cycle. - The transmitter shall be capable of operation with a continuous duty cycle.

3. 5. 13. 2. 12 Mechanical dimensions. - The VHF transmitter shall be contained in a three-eights ATR short chassis. The weight shall not exceed 14 pounds.

3. 5. 13. 2. 13 Shockmount. - The VHF transmitter and receiver shall be mounted in a Collins type 390E-2 dual shockmount assembly or its equivalent. All connections to the transmitter and receiver shall be made at the rear of the shockmounting assembly.

3. 5. 13. 2. 14 Transmitter type of emission. - The transmitter shall provide an amplitude modulation (A-3) signal.

3. 5. 13. 2. 15 Harmonic and spurious radiations. - With the transmitter terminated into a 52 ohm load the harmonic emissions shall be down at least 45 DBW with other spurious emissions down at least 75 DBW.

3. 5. 13. 2. 16 Control head functions. - The control head shall contain controls for the following functions:

a. Volume: A knob control shall be provided for setting the receiver audio output level.

b. Squelch: A knob control shall be provided for setting the squelch level.

c. On-off: A toggle switch shall be provided for controlling the 400 cycle AC voltage input to the transmitter and receiver.

d. Channel selection: A control shall be provided for selection in 50 kilocycle steps of frequencies within the 108 to 151. 95 megacycle range.

3. 5. 13. 2. 17 VHF antenna. - A vertically polarized omnidirectional antenna shall be mounted externally on the van. It shall be capable of operation in the VHF frequency range of 116 to 150 megacycles, with a nominal 52 ohm input impedance. Antenna type shall be Telrex X100200 or equivalent.

3. 5. 13. 3 Intershelter communications. - A wireless intercommunications equipment shall be included in the AN/TPN-14 shelter to permit intercommunications with other shelters in the system and with other facilities which are equipped to receive information by this modulation process.

3. 5. 13. 3. 1 General description. - The intercommunications equipment shall utilize the Martin Company Random Access and Correlation for Extended Performance (RACEP) Discrete Address System, or its compatible equivalent for encoding, transmitting, receiving and decoding voice messages. Inherent in this technique is the discrete digital address for each station in the network which will permit direct and private contact between any combination of pairs of stations in the network, or directly between a command station and all subordinate stations.

3. 5. 13. 3. 2 Primary station. - The AN/TPN-14 shall have one primary station. This primary station shall consist of one enclosed chassis containing the input audio circuit, the coder, the transmitter, the receiver, the decoder, the output audio circuit, a station code selector, a ringing device, an alarm device, a call indicator and a 400 cycle to 28 volt DC converter; one whip antenna with coaxial feed; a telephone-type handset; and a loudspeaker-microphone combination.

3. 5. 13. 3. 3 Mode of transmission and reception. - Transmission of all messages shall occur in a spectrum four megacycles wide in the VHF band. Message separation shall be achieved by the transmission of pulse triples, each on a different RF frequency and each with a particular time of occurrence in accordance with the RACEP technique. The order in which the three pulses are transmitted shall constitute an address and there shall be one such discrete address for each intercommunications station in the network.

3. 5. 13. 3. 3. 1 The three pulses shall be transmitted at those specific frequencies in the VHF range. The three frequencies shall consist of a center frequency plus a frequency one megacycle on either side of it. The center frequency shall be specified at a later date by the cognizant technical agency.

3. 5. 13. 3. 3. 2 Pulse-triples shall be transmitted at a rate of 8, 000 pulse-triples per second.

3. 5. 13. 3. 3. 3 Each pulse shall have a pulse-width of 1. 7 ±10% microsecond.

3. 5. 15. 1 Electrical operating range. - The air conditioner shall be designed to operate from alternating current power sources having the following characteristics:

a. Potential (steady): 115/208 volts plus or minus 5 percent
b. Frequency: 400 cycles per second plus or minus 5 percent
c. Phase: Three phase, four wire
d. Maximum fluctuation in frequency: Plus or minus 2 percent

3. 5. 15. 6. 5 Flexible air ducts. - The air conditioner shall be provided with flexible and insulated supply and return air ducts for connecting the air conditioner to the shelter being serviced. The ducts shall have a nominal diameter of 10 inches and shall be 20 feet long.

3. 5. 15. 6. 5. 1 The ducts shall be of a construction that is reinforced by a helical wire stiffener core that tends to extend the duct when released and shall be compressible to 30 percent of the extended length for storage. The end connections shall be designed to provide proper sealing against air leakage at the joints. The material used in fabricating the ducts shall be flexible (at all operating ambient temperatures), nonpermeable, fuel and oil resistant, and shall be capable of withstanding all operating and storage conditions applicable to the air conditioner.

3. 5. 15. 6. 5. 2 The insulation shall be at least 0. 5 inch nominal thickness and uniformly distributed over the surface of the duct and adequately anchored to prevent shifting.

3. 5. 15. 7. 4 Condenser. - The condenser shall be of an air-cooled, brazed aluminum, plate fin, extended-surface type. It shall have adequate surface to enable the air conditioner to perform its cooling function under extreme ambient and return air conditions consistent with maximum power limitations. The condenser shall withstand, without deformation or leakage, an internal pressure equal to 1. 5 times the saturated refrigerant pressure at 71 degrees Centigrade. Condensation from the evaporator coil shall not be used to provide additional cooling effect.

3. 5. 15. 7. 6 Evaporator. - The evaporator shall be of the brazed aluminum plate fin type and shall be of adequate size to limit the air velocity at the face of the core to approximately 850 feet per minute. The evaporator shall withstand without deformation or leakage, an internal pressure equal to 1. 5 times the saturated refrigerant pressure at 71 degrees Centigrade.

3. 5. 15. 11. 4 Power receptacle. - The power receptacle shall be a Crouse-Hinds square flanged receptacle similar to part number RPC233-014-S-2AR except that a R02AR insert is required in place of the S02AR insert, or equal.

3. 5. 15. 11. 5 Power cable assembly. - A power input cable complete with connectors shall be provided. The cable shall be an extra-flexible, five-conductor, number 10AWG, jacketed cable conforming to Specification MIL-E-4158, and shall be 35 feet in length. The conductors shall be insulated with type IS-1 insulation conforming to Specification MIL-I-3930A. The cable jacket shall be type JN-L conforming to Specification MIL-I-3930A. A Crouse-Hinds cord connector plug similar to part number RPC133-152-P02AR except that a S02A insert is required in place of the P02AR insert or equal shall be provided on one end of the cable. A Crouse-Hinds cord connection plug similar to part number RPC-133-152-P02AR except that solder type contacts are required in place of the solderless contacts or equal, shall be provided on the other end of the cable.

3. 5. 15. 12. 2 Accessibility. - The inclosure shall be so designed that components and assemblies can be easily removed therefrom.

3. 5. 16 Gas turbine powered generator. - This section establishes the design and performance requirements for a 20 kilowatt constant frequency, alternating current generator set powered by a gas turbine, and contains the necessary detail information to define the generator set. The generator set defined in this specification is self-contained, enclosed, and composed of a gas turbine prime mover with controls; a generator with regulator; and instrument and control panel; line contactors and controls; battery, fuel tank, and enclosure.

3.5.18.2 Clock. - An eight day wind clock shall be provided with the AN/TPN-14. It shall be located in accordance with good human engineering practices where it can be viewed by a man seated at the Az-El indicator.

4.3.2.3 Flight tests. - The AN/TPN-14 shall be set up and flight tested at a site within the continental United States, as designated by the procuring activity. The contractor shall provide a minimum of one qualified engineer and two qualified technicians to set up, align, maintain and operate the AN/TPN-14 during the flight tests. The contractor shall also provide qualified data takers and analysts as required. The Air Force activity cognizant of the flight tests shall provide or arrange for the test site and necessary aircraft. The test aircraft shall be of a modern type presently in the Air Force Operational Inventory which will provide a "head-on" target area of approximately one square meter.

4.3.2.3.1 Scope of tests. - The AN/TPN-14 shall be tested, and data recorded, for the following:

a. Manpower and time for deployment and alignment
b. Manpower and time for disassembly and stowage for transport
c. Ease of alignment, calibration and repair
d. Mean-time-to-failure
e. Mean-time-to-repair
f. Overall accuracy
g. Suitability of equipment configuration from both operational and maintenance standpoint
h. Antenna propagation configuration
i. Frequency of use and suitability of test equipment.

4.3.2.3.2 Antenna pattern tests. - A series of runs shall be made to collect data on the horizontal coverage of the elevation antenna and the vertical coverage of the azimuth antenna. During these flights the azimuth antenna shall be tilted to plus 3 degrees. The elevation antenna shall be servoed to the runway center line. The flights shall be made with the azimuth and elevation antennas in each of the following modes of operation:

a. Linear polarization with no cosecanting of the elevation antenna
b. Linear polarization with left-of-runway cosecant plates attached to the elevation antenna
c. Linear polarization with right-of-runway cosecant plates attached to the elevation antenna
d. Circular polarization with no cosecanting of the elevation antenna

4. 3. 2. 3. 2. 2 Data recording. - Antenna propagation charts shall be plotted for both the azimuth and elevation antennas in each mode of operation as specified in (a) through (d) in 4. 3. 2. 3. 2. The method used for recording the antenna pattern data shall be the 0-4 video signal strength readings obtained by monitoring the radar control indicator. The frequency of recording the signal strength shall be no less than the following:

a. 0-10 mile range - each one-half mile

b. 10-20 mile range - each mile

Advance copies of the test data shall be submitted by the contractor to the procuring activity as soon as tests are completed.

4. 3. 2. 3. 3. 3 Data recording. - Data shall be collected, charted and analyzed to demonstrate:

a. Accuracy and linearity of AN/TPN-14 center line

b. Accuracy and linearity of AN/TPN-14 guide slopes

c. Degree of correlation between theodolite readings of azimuth and scope photograph measurement of azimuth at each one-quarter mile increment of range.

d. Degree of correlation between theodolite readings of elevation angle and scope photograph measurements of elevation angle at each one-quarter mile increment of range.

e. Azimuth and elevation dispersion pattern of aircraft position at each quarter mile of range based on theodolite readings.

4. 3. 2. 7 Operational data. - The following operational data shall be supplied by the contractor to the procuring activity at least forty-five days prior to the start of qualification test.

a. Twelve copies of a cabling diagram of the AN/TPN-14

b. Twelve copies of outline dimensional sketches of all major and minor assemblies and any detailed parts not internal therein, showing projections.

c. Twelve copies of a brief instructional manual. The manual shall cover all installation and operating procedures necessary to enable untrained, but technically qualified personnel to perform operational suitability tests on the radar set. The manual shall also include any information required for the maintenance of contractor-furnished equipment.

d. Twelve copies of a practical wiring diagram of each contractor-furnished component or of each constructional unit thereof, whichever is practical, showing the physical location and connections of detailed parts and subassemblies with reference symbols and terminal numbers indicated.

4.3.2.8 Qualification test report. - After the contractor completes the qualification tests, he shall prepare a complete test report in accordance with Specification MIL-T-9107. He shall furnish twelve complete copies of this report to the procuring activity no later than twenty days following completion of the Qualification Tests.